DOCUMENT RESUME

ED 093 323 IR 000 810

TITLE	Scientific and Technical Information Transfer for Education (STITE).
INSTITUTION	Georgia Inst. of Tech., Atlanta. School of Information and Computer Science.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Jul 73
NOTE	200p.
EDRS PRICE	MF-$0.75 HC-$9.00 PLUS POSTAGE
DESCRIPTORS	*Data Bases; Information Needs; Information Processing; *Information Retrieval; *Information Systems; Instructional Innovation; Instructional Technology; Literature Reviews; Program Descriptions; *Science Education; Technical Reports
IDENTIFIERS	Learning Information Systems; *STITE

ABSTRACT

STITE (Scientific and Technical Information Transfer for Education) is a proposed system for the transfer of information from the many computerized information banks to the field of science education. A description of STITE with its auxiliary systems first outlines the goals and objectives of the research. Next, selected science and technology centers are analyzed. A description of several learning information systems (instructional methodology and technology) is presented. The design and operation of the STITE system is detailed. A literature survey of the field concludes the report. (WH)

ED 093323

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

RESEARCH REPORT

SCIENTIFIC AND TECHNICAL INFORMATION TRANSFER FOR EDUCATION

(STITE)

JULY, 1973

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

IR 000 810

SCIENTIFIC AND TECHNICAL INFORMATION AND TRANSFER FOR EDUCATION

(STITE)

Progress report on research performed under National Science Foundation Grant No. GN-36114

July 1973

Project Director	:	Pranas Zunde
Staff (faculty)	:	Miroslav Valach
Staff (non-faculty)	:	Frank Chu
		Khalid Hafiz
		Dorothy S. Hughes
		N. V. Subramanian

SCHOOL OF INFORMATION AND COMPUTER SCIENCE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA

TABLE OF CONTENTS

SOME OF THE ABBREVIATIONS USED IN THIS REPORT 3

PART ONE - GOALS AND OBJECTIVES OF RESEARCH 4

- I. Introduction 5
- II. Science Information and Education 7
- III. Research Objectives and Phase I Tasks 8
- IV. References 12

PART TWO - ANALYSIS OF SELECTED SCIENCE AND TECHNOLOGY CENTERS. 13

- I. Introduction. 14
- II. Categorization of Science and Technology Information Centers. 16
- III. Analysis of STICs 29
- IV. Tabulation of Operational Characteristics of Selected STICs . 35
- V. References 67
- VI. Conclusion 69

PART THREE - DESCRIPTION OF LEARNING INFORMATION SYSTEMS. 71

- I. Introduction. 72
- II. The Teaching Situation. 73
- III. The Process of Developing Science Learning Materials. 76
- IV. Programmed Instructional Materials 83
- V. Computer-Assisted Instruction 91
- VI. Audio-Visual Techniques 96
- VII. The Self-Instruction System, "ALF". 99
- VIII. Conclusion. 103
- IX. References. 105

PART FOUR - DESIGN AND OPERATION OF THE STITE SYSTEM 106
I. Examples of Features of STITE and their Possible Uses 107
II. The Teacher's Role in Use of STITE System 108
III. Operational Scheme of STITE 109
IV. Design Concepts of STITE System 118

PART FIVE - LITERATURE SURVEY 126
I. Introduction 126
II. Scope of the Literature Survey 127
III. Science and Technical Information Centers/Systems 127
IV. Analysis and Design of Science Information Transfer Systems . . 129
V. Learning Systems and Tools 143
VI. References 159
VII. List of Sources Checked 160

APPENDIX 162
A. Sample of Letter Requesting Information 163
B. List of Institutions Contacted 164
C. Report of Visit from Allen Humphrey of Institute of Library Research 165
D. Interview of National Medical Audio-Visual Center 166

SOME OF THE COMMON ABBREVIATIONS USED IN THIS REPORT

STITE - Scientific and Technical Information Transfer for Education

LIS - Learning Information System

STIC - Science and Technical Information Center

UDC - Universal Decimal Classification

PART ONE

GOALS AND OBJECTIVES OF RESEARCH

PART ONE

GOALS AND OBJECTIVES OF RESEARCH

I. INTRODUCTION

Research and development in the field of science information during the past decade has resulted in the establishment of large banks of descriptive information and bibliographic data. Stored on digital and analog media, these collections, along with the organization and dissemination of their data and information, comprise science and technical information centers, or science information systems.

So far, the almost exclusive clientele of science information systems has been the community concerned with research, development and production of either ideas or goods. It is logical that the scientific and technical research community be considered as the principal beneficiary of science information systems: the impetus for the establishment of these systems was given by concern with the efficiency of scientific research and development in a society in which both the quantity of science information and the number and variety of its users have registered a substantial growth trend. At the same time, however, the scientific research community as a market is not characterized by either the volume or the frequency of information use which would exhaust the capacity and potential of present-day science information systems. It is thus very appropriate to inquire whether the contents and services of these systems can be made available to science endeavors other than research and development. The appropriateness of this inquiry is unquestionable; science information is a social and national resource whose value potential is closely related to the level of its prudent use.

In searching for other markets for science information, the obvious direction is to look toward human activities which are heavily dependent on information inputs from external "science memories." Obviously, human science learning is an example of such an activity which fundamentally depends on information transfer from external information sources into the human mind. Science education, the organized social system for such learning, is intuitively an attractive market for science information.

The notion of a symbiosis between science information and learning is not new, although until very recently it has received little overt attention. Watson Davis [Ref.1],is reported having observed "a curious lack of follow-up among documentalists" to the Utopian idea of a "world brain" suggested by H. G. Wells--a centralized store of knowledge used for education. More recently, the Interuniversity Communications Council proposed to bring the contents of various existing and potential information stores to bear on the educational process; after an initial period of enthusiasm [Ref.3], the concept still remains to be seriously explored, as do the premises which led to the "networks for knowledge" Federal legislation of the mid-1960's. Apart from a few serious advocates of such a symbiosis [Ref.4], the respective orientations of science information and education have remained diverse, even on occasions when the two met to communicate on a shared platform of educational technology.

Within the past year, however, several events are indicative of a high level concern with the relationship of science information and education. Prominent among these is a study by the Organization for Economic Cooperation and Development entitled Information for a Changing Society (OECD, 1971). In response to a major conclusion of this study (that "information systems of the future must be dynamic, capable of educating, and adaptable to the changing educational systems of the world") OECD recommends that "evaluation of educational requirements of modern societies should take account of the need for information transfer systems that are better adapted to the continuing re-education of adults."

In a parallel vein, specific attention has now been drawn to the necessity of adapting science information systems to the science educational process and system of the future: "The information systems stimulated by the National Science Foundation have heretofore focused primarily on the needs of specialists; greater attention should be paid to the life-long educational process of the [scientific] non-specialist" [Ref.2].

II. SCIENCE INFORMATION AND EDUCATION

In the context of the work reported here, science information is defined as recorded knowledge, usually in the form of primary publications stored on analog or digital media, emanating from the intellectual work of the scientific and technical community. The management of the inventory of science information, and the enhancement of its utility to mankind, are the primary purposes of science information systems. In the attempt to meet these purposes, science information systems collect, evaluate, organize and store science information, and they provide tools for its purposeful use. In modern science information systems, the tools comprise primarily devices and mechanisms for accessing science information—devices and mechanisms such as descriptive notations, indices, abstracts, searching methods, etc. The function of science information systems may be said to be that of a couple between science information and its users, insofar as present-day systems are generally limited only to the storage of science information surrogates.

In their role of searchable bibliographic directories the use of science information systems is not limited to the research community; their use by others depends, however, on their need for science information and on its utility. For reasons which remain to be carefully assessed the use of science information systems in science education has been sporadic, and largely confined to individuals engaged in research rather than in scientific or technical instruction or learning. It is quite apparent that the flow of science information into science education is characterized by discontinuity, lack of intensity, and time delay; hence its utilization in science education is suboptimal.

Unless the use of science information systems in science education is to be for purposes other than an occasional bibliographic search on a topic of momentary interest, the possibility of an effective flow of science information into education appears to be predicated on the existence, availability and use of external, manipulable stores of learning materials. A direct flow of science information from its repositories into the highly volatile and transitive environment of live classroom instruction is difficult to imagine; the updating of the knowledge of human instructors is an idiosyncratic process of habitual characteristics which are not easily modified. On the other hand, stored learning materials (textbooks, instructional films, etc.) are a solid client of science information services, and a strong element in the educational process.

The realistic possibility of an intensified influx of science information into instruction and learning in the sciences is therefore given by the recent emergence and development of "learning systems," broadly defined as technology-aided instruction/learning facilities which allow learners to interact with organized learning materials stored in an animate, manipulable device or memory. The more powerful of these systems are "conversational"--that is, interactive systems which provide, in addition to a modular store of learning materials, models of the live interaction between a student and a human tutor. Despite the relative simplicity of the present-day models, the conversational learning systems hold promise of being able to sustain realistically the process of self-instruction. Furthermore, given certain types of memories of learning materials to support the self-instruction process, it is possible to consider science information as constituting an important input into these systems.

III. RESEARCH OBJECTIVES AND PHASE I TASKS

The objective of the proposed project is to study, design and experimentally evaluate man-machine mechanisms for enhancing the transfer of science information from its present repositories into science learning systems.

The postulated mechanism for the transfer of science information into learning systems, which can only be sketched at this time, is illustrated in Figure 1. The main characteristic of this transfer mechanism is the use of certain outputs of science information systems, enhanced and modified as appropriate, as inputs to the learning systems. The transformation of the outputs, and the ease and economy with which the transfer can be accomplished, are the crucial aspects of the mechanism. It is unlikely that the process can be performed fully automatically; rather, the educator-author is the key human interface responsible for the transformation of information.

Within its general objective of investigating the mechanisms of science information transfer into science education, the ongoing research has the following specific goals:

1. To describe operationally the human process of transformation of science information system outputs for the purpose of integrating them into the content of ALF-type learning systems;

2. To investigate comparatively the design and operating characteristics of science information systems and ALF-type science learning systems, particularly from the viewpoint of requirements for transferring information between them via a man-machine interface;

3. To implement an experimental design of limited transfer mechanism from appropriate existing science information systems into an ALF-type science learning system, and to evaluate selected aspects of that mechanism.

The findings of the proposed research should result in conclusions concerning the minimum design requirements for the compatibility of science information systems and science learning systems, and in an evaluation of an operational method for a rapid integration of up-to-date science information into the content of modular facilities for self-instruction in science.

In the first phase of the project, research efforts were focused on the following tasks:

1. Analysis of relevant paramters of existing science information systems.

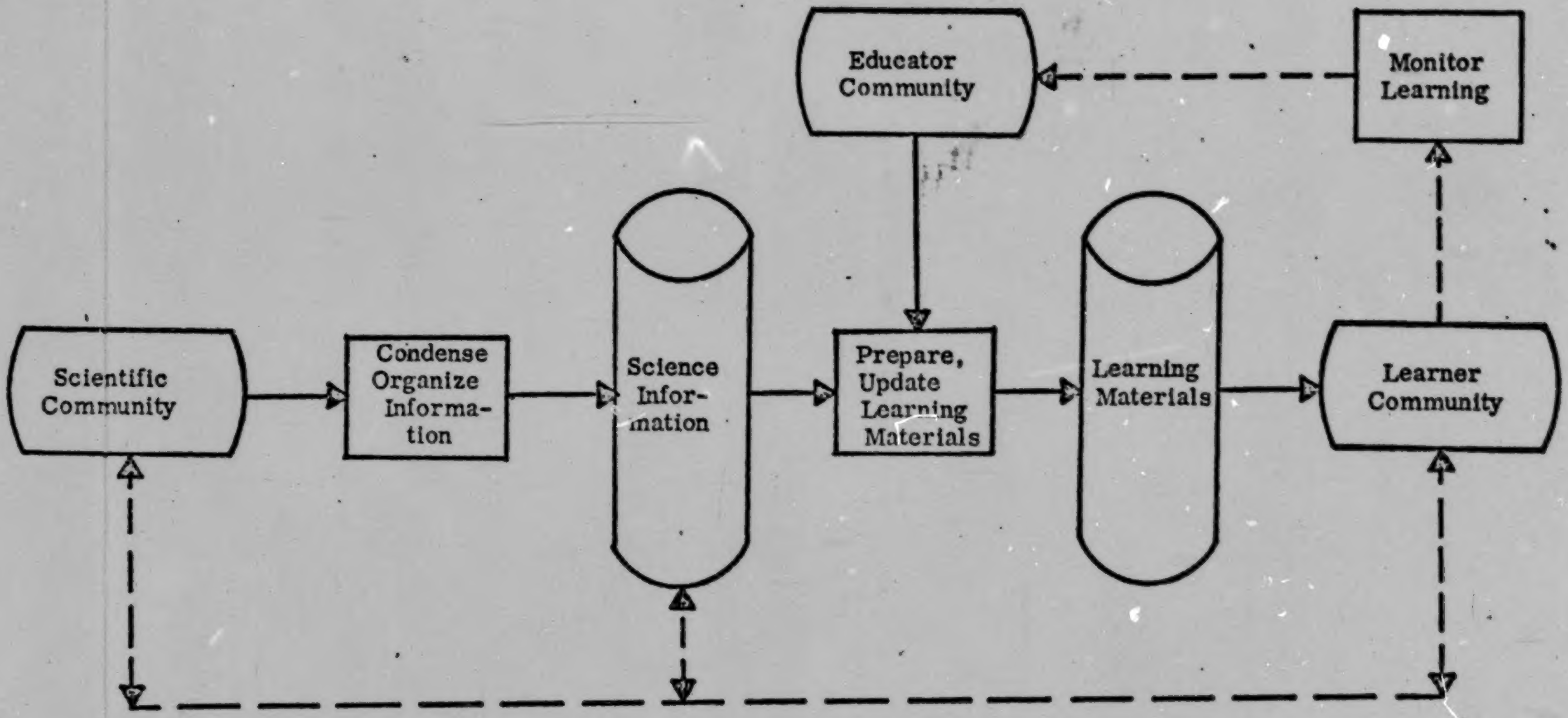

Educator Community
Monitor Learning
Scientific Community
Condense Organize Information
Science Information
Prepare, Update Learning Materials
Learning Materials
Learner Community

Fig.1 . Utilization of Science Information in Learning Systems

2. Human interface characteristics for science information transfer.
3. Investigation of design alternatives of the STITE system.

The above tasks and the state of research are described in greater detail in the remaining sections of this report. An initial, although not yet complete, review of relevant literature is also included.

IV. REFERENCES

1. Bohnert, H., and Kochen, M. "The Automated Multilevel Encyclopedia as a New Mode of Scientific Communication." Proceedings of ADI, 2:269-270 (1963).

2. Brady, E. L., and Branscomb, L. M. "Information for a Changing Society." Science, 175:961-966 (March 3, 1972).

3. Brown, G. W., et al. EDUNET--Report of the Summer Study on Information Networks. New York, Wiley, 1967.

4. Kochen, M. "Information Science and Computer Aids in Education." In Schultz, L., ed., The Information Bazaar, Philadelphia, Pa., the College of Physicians, 1969, pp. 209-226.

PART TWO

ANALYSIS OF SELECTED SCIENCE AND TECHNICAL INFORMATION

PART TWO

ANALYSIS OF SELECTED SCIENCE AND TECHNICAL INFORMATION

I. INTRODUCTION

The prominent products of research and development in science/technical information of the past decade are large banks of descriptive information and bibliographic data stored on digital and analog media. The collection, organization, and dissemination of this information and data comprises the so called "Science and Technical Information Systems/Center" (STIC), whose services typify the current level of development of the information industry - the establishment of computerized information utilities and services of different types and purposes. Science and technical information centers differ widely when considered from the viewpoint of the degree of automation, the depth and breadth of subject coverage, their sources of information. their operational characteristics and their availability to user community. By user community is meant the total user population of the center.

The distinctions between different science information systems also relate to the fact that there are various methods for each of the stages of operation, such as acquisition, record keeping, library processing and loans, storage of the sources, information dissemination, information searching, information retrieval etc.

The science and technical information system/center can further be defined as an information service system which operates in an environment which includes both information to be processed and a population of users who require various portions of this information in order to achieve certain goals. For example, the goal of the proposed science information transfer system, STITE, is to design learning materials and to update them periodically, thereby enhancing the effectiveness of the learning systems in modern educational methods.

The following figure delineates the major subsystems/components of the proposed system.

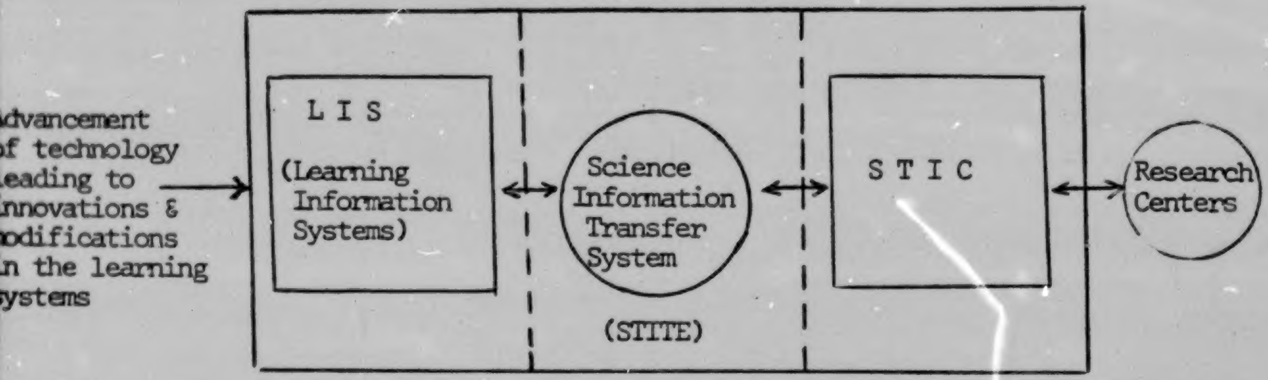

dvancement
f technology
eading to
nnovations &
odifications
n the learning
ystems
L I S
(Learning
Information
Systems)
Science
Information
Transfer
System
(STITE)
S T I C
Research
Centers

Fig. 2

The above figure shows the information flow in the proposed STITE system. The main aim of this research project is the design of this central system. As technology advances and brings down the cost of equipment, such as audio-visual equipment and data transmission devices, there will be innovations and modifications in learning information systems (LIS). This will continually alter the information requirements of LIS, and consequently its interactions with the STITE system will enhance with time.

As it is anticipated at this phase of the project, the STITE system would be an intermediary office between the LIS and STICs with computing and data processing facilities. On the basis of requests from the educator community (i.e. LIS), the STITE system would interact with STICs according to some pre-programmed fashion and according to its intended purpose, it would acquire the necessary information from the STICs and provide the same to the appropriate LIS. The selection of media for information transmission between the components of the proposed system, as shown in the above figure, is one of the main features of the design of the proposed information transfer mechanism. It can be anticipated that there would be a gradual transition from off-line to on-line, and from batch to real-time transmission.

A few basic assumptions are made concerning science information systems and the design philosophy of the proposed science information transfer system.

1) The science information centers will have direct contact, or contact via an intermediary office, with the user community on an initiative as well as on a responsive basis.

2) Not all of the learning systems will require the transfer of information from science information systems to learning systems. This variation will necessitate further research defining the criteria for the use of STITE system and identifying the courses that need updating with the science information to be transferred from these centers.

3) There may be an additional performance requirement on these science information centers to publish periodicals that will assist the educator community in the development of new courses to be offered to learners for enhancing their knowledge with current research results.

4) It is further assumed that to determine the science information centers to be accessed for the development of new courses in a given subject area and to facilitate the identification of centers that will provide the necessary science information for updating the learning materials for modifying the course preparation in a given subject area, it is necessary to categorize these centers on the basis of subject disciplines.

II. CATEGORIZATION OF SCIENCE AND TECHNICAL INFORMATION CENTERS

As previously mentioned it is necessary for the STITE system to identify the centers that will be contacted for retrieving the relevant information for the educator community. As a preleminary step to this, it is reasonable to assume that existing science and technical information centers should be categorized on the basis of subject disciplines. Each science information center presently has a classification of information according to several profile interests in a subject discipline. This facilitates retrieving from the store the portion of the information that a particular user needs. Also it indicates that it is not necessary to further categorize the centers on the basis of detailed profile interests in a subject discipline.

Kruzas, in Encyclopedia of Information Systems and Service [Ref. 9], gives a page description of approximately 1000 STICs. All entries include the name of the parent organization and the particular system, service or activity described, date established, other sponsoring organizations, head of the unit, staff, description of system, scope or subject coverage, input sources, holdings of recorded data, serial publications, non-serial publications, microform services, magnetic tape services, and other services provided by the center, such as abstracting, indexing, literature searching (computer as well as manual), data collection and analysis, network and cooperative programs.

Kruzas [Ref. 9], also gives 12 valuable indexes, the primary one of which is the subject index. This has been the primary source of information for the following subject categorization of STICs.

For convenience, science information centers have been classified on the basis of subject disciplines into categories which correspond to the major subject subdivisions of the Universal Decimal Classification (UDC).

If a STIC is listed under a particular subject heading then that is an indication that STIC has some science and technical information in that subject discipline. Here the categorization is broad, and there is a considerable degree of overlapping between subject headings. Kruzas's listing of STICs in the subject index [Ref. 9],has been extensively used here.

II. CATEGORIZATION OF STICS IN SCIENCE

1. Science

General Science

-Information Interscience Inc. - Science Information Center.

-Institute for Scientific Information.

-Johns Hopkins University - Center for Research in Scientific Communication.

-Ohio State Univ. - Mechanized Information Center.

-Penn State Univ. - Penn. State Tech. Assistance Program.

-Quantum Science Corporation.

-Scientist' Institute for Public Information

-Smith, Kline, and French Labs - Science Information.

-U.S. Committee on Scientific and Technical Information.

-U.S. National Academy of Sciences - National Research Council - Office of the Foreign Secy.

Mathematics

- -American Mathematical Society - Mathematical Off print Service.
- -Johns Hopkins University - Applied Physics Lab.
- -U.S. Office of Education - ERIC Clearinghouse for Science and Math Education.
- -Univ. of Oklahoma Medical Center - Medical Center Computing Facility.

Astronomy & Allied Sciences

- -American Inst. of Physics - National Information System for Physics and Astronomy.
- -U.S. Air Force - Aeronautic Chart and Information Center.
- -U.S. National Oceanic and Atmospheric Admin. - World Data Center, A - Upper Atmosphere Geophysics.
- -Wolf Research and Dev. Corp.

Physics

- -American Institute of Physics - National Information System for Physics and Astronomy.
- -Institute of Electrical and Electronics Engineers - Information Service Department.
- -Johns Hopkins University - Applied Physics Laboratory - Information Storage and Retrieval Project.
- -U.S. Army - Materiel Command - Harry Diamond Laboratories - Scientific and Technical Information Office.
- -U.S. Atomic Energy Commission - Oak Ridge National Laboratory - Central Research Library.
- -U.S. Atomic Energy Commission - Oak Ridge National Laboratory - Nuclear Data Project.
- -U.S. Atomic Energy Commission - Oak Ridge National Laboratory - Research Materials Information Center.
- -U.S. Bureau of Mines - Albany Metallurgy Research Center - Thermodynamics Laboratory - Contributions to the Data on Theoretical Metallurgy.
- -U.S. Bureau of Standards - Atomic Transition Probabilities Data Center.

-U.S. National Bureau of Standards - Office of Standard Reference Data - National Standard Reference Data System.

-U.S. Navy - Naval Research Laboratory - Technical Library.

-University of Calgary - Information Systems and Services Division.

-Stanford University Computation Center - Stanford Physics Information. Retrieval System.

-University of California - Lawrence Radiation Laboratory - Berkeley Particle Data Center.

Chemistry

-Abbott Laboratories - Information Services.

-American Chemical Society - Chemical Abstracts Service.

-American Chemical Society - Division of Chemical Literature.

-American Cyanimid Company - Lederle Laboratories - Research Information and Retrieval Department.

-American Petroleum Institute - Central Abstracting and Indexing Service.

-Chemical Systems, Inc. - Computerized Structural Group Index of Commercial Organic Chemicals.

-Ciba Pharmaceutical Company - Scientific Information Center.

-De Soto Inc. - Information Center.

-Drug Information Association.

-Eli Lilly and Company - Scientific Library.

-Ethyl Corporation - Research Laboratories - Technical Information Services.

-Franklin Institute - Research Laboratories - Science Information Services Department.

-Goodyear Tire and Rubber Company - Goodyear Atomic Corporation - Information and Records.

-Hoffmann-La Roche Inc. - Management Service Department.

-Hooker Chemical Corporation - Technical Information Center.

-Illinois Institute of Technology - IIT Research Institute - Computer Search Center.

-Iowa State University - Institute for Atomic Research - Rare-earth Information Center.

-Lockheed Aircraft Corporation - Lockheed Missiles and Space Company Technical Information Center.

-Norwich Pharmacal Company - Information Services Division.

-Plenum Publishing Corporation - Princeton Information Technology.

-Predicasts, Inc.

-Rensselaer Polytechnic Institute - Molten Salts Data Center.

-Schering Corporation - Scientific and Technical Information Center - Technical Documentation Department

-Science Databank, Inc.

-Smith, Kline and French Laboratories - Science Information.

-Southwest Research Institute - Information Services and Library.

-Squibb Institute for Medical Research - Science Information Department.

-Stanford Research Institute - Chemical Information Services.

-Texas A & M University - Department of Chemistry - Thermodynamics Research Center.

-3M Company - Scientific and Technical Communications Department - Patents and Profiles.

-3M Company - Scientific and Technical Communications Department - Technical Communications Centers.

-U.S. Army - Edgewood Arsenal - Industry Liaison Office - Wiswesser Chemical Line Notation System.

-U.S. Army - Electronics Command - Technical Information Division.

-U.S. Atomic Energy Commission - Oak Ridge National Laboratory - Central Research Library.

-U.S. National Bureau of Standards - Chemical Kinetics Information Center.

-U.S. National Bureau of Standards - Chemical Thermodynamics Data Center.

-U.S. National Bureau of Standards - Crystal Data Center.

-U.S. National Bureau of Standards - Data Center for Atomic and Molecular Ionization Processes.

-U.S. National Bureau of Standards - Diatomic Molecule Spectra and Energy Levels.

-U.S. National Bureau of Standards - Office of Standard Reference Data National Standard Reference Data System.

-U.S. Navy - Naval Research Laboratory - High Temperature Behavior of Inorganic Salts.

-U.S. Patent Office - Office of Search Systems and Documentation - Classification System.

-U.S. Public Health Service - National Institutes of Health - Clinical Pathology Data Processing System.

-University of California - Lawrence Radiation Laboratory - Information Research Group.

-Xerox Corporation - Central Information Center.

Earth Sciences

-Geoscience Information Society.

-Ohio State University - Institute of Polar Studies.

-U.S. Air Force - Aeronautic Chart and Information Center - Technical Library Section.

-U.S. Army - Electronics Command - Technical Information Division.

-University of Michigan - Subsurface Laboratory - Geologic Educational Research Center.

-University of Tulsa - Information Services Department.

Paleontology

--American Geological Institute - Geological Reference File.

-McLean Paleontological Laboratory - Information Services.

Biology

-Biosciences Information Service of Biological Abstracts.

-Illinois Institute of Technology - IIT Research Institute - Computer Search Center.

-Johns Hopkins University - Laboratory in Behavioral Physiology - Communications in Behavioral Biology.

-Universite Laval - Centre de Documentation.

-University of California - Lawrence Radiation Laboratory - Information Research Group.

Botanical Sciences

-University of Miami - Morton Collectanea.

2. Technology

Technical Sciences

- American Petroleum Institute - Central Abstracting and Indexing Service.
- Battelle Memorial Institute - Columbus Laboratories - Strategic Technology Information Analysis Center.
- Chevron Oil Field Research Company - Technical Information Center.
- Dallas Geological Society - Geological Information Library of Dallas.
- Esso Research and Engineering Company - Company and Literature Information Center.
- Esso Research and Engineering Company - Engineering Information Center.
- Ethyl Corporation - Research Laboratories - Technical Information Services.
- General Dynamics Corporation - Convair Aerospace Division - Library and Information Services.
- Harvard University and Massachusetts Institute of Technology - University Information Technology Corporation.
- Illinois Institute of Technology - Institute of Gas Technology Technical Information Services.
- Indiana University - Aerospace Research Application Center.
- Interuniversity Communications Council.
- Johns Hopkins University - Applied Physics Laboratory - Information Storage and Retrieval Project.
- Lockheed Aircraft Corporation - Lockheed Missiles and Space Company - Technical Information Center.
- Marathon Oil Company - Denver Research Center - Technical Information Section.
- Martin Marietta Corporation - Technical Information Center.
- Mobil Research and Development Corporation - Field Research Laboratory - Technical Information Section and Library.
- North American Rockwell Corporation, Inc. - Aerospace and Systems Group Technical Information Processing System.
- Sandia Laboratory - Technical Libraries Department.
- Southwest Regional Laboratory for Educational Research and Development - Computer Center.
- United Aircraft Research Laboratories - United Aircraft Corporation Library System.

-University of Iowa - Iowa Educational Information Center.

-University of Southern California - Western Research Application Center.

-University of Tulsa - Information Services Department.

-University of Utah - College of Engineering - Solid Rocket Structural Integrity Information Center.

-U.S. Army - Electronics Command - Technical Information Division.

-U.S. National Aeronautics and Space Administration - Manned Spacecraft Center - Technical Library.

-U.S. National Aeronautics and Space Administration - National space Science Data Center.

-U.S. National Aeronautics and Space Administration - Scientific and Technical Information Facility.

-U.S. National Aeronautics and Space Administration - Scientific and Technical Information Office.

-U.S. National Oceanic and Atmospheric Administration - Scientific Information and Documentation Division.

-U.S. Navy - Naval Research Laboratory - Technical Library.

-U.S. Office of Education - ERIC Clearinghouse on Educational Media and Technology.

-Wolf Research and Development Corporation.

-World Data Center A - Rockets and Satellities.

Medical Sciences

-Abbott Laboratories - Information Services.

-American Medical Association - Archive - Library.

-Canada - National Research Council of Canada - National Science Library of Canada - Health Sciences Resource Center.

-Catholic Hospitals Medical Education Foundation - Medical Literature Information Center.

-Ciba Pharmaceutical Company - Scientific Information Center.

-John Crerar Library - Research Information Service.

-Excerpta Medica Information Systems, Inc. - Automated Storage and Retrieval System of Drug Literature.

-Houston Academy of Medicine Library - Cooperative Automated Circulation System.

-Institute for Advancement of Medical Communication.

-Lowry-Cocroft Abstracts.

-Mead Johnson and Company - Medical Services.

-Medical Library Center of New York.

-Memorial Sloan Kettering Cancer Center - Memorial Hospital for Cancer and Allied Diseases - Communication and Computation Center.

-Mid-Continental Regional Medical Library.

-Pacific Northwest Regional Health Sciences Library.

-Pharmaceutical Manufacturers Association - Science Information Service.

-South Central Regional Medical Library Program.

-Southeastern Regional Medical Library Program.

-U.S. National Library of Medicine.

-U.S. National Library of Medicine - Lister Hill National Center for Biomedical Communications.

-U.S. National Library of Medicine - Medical Literature Analysis and Retrieval System.

-U.S. National Library of Medicine - National Medical Audiovisual Center.

-U.S. Public Health Service - National Institutes of Health - National Institute of Arthritis and Metabolic Diseases - Office of Scientific Communications.

-U.S. Public Health Service - National Institutes of Health - National Institute of Mental Health - Division of Narcotics Addiction and Drug Abuse - Addiction Research Center.

-U.S. Public Health Service - National Institute of Occupational Safety and Health - Scientific Reference Service Branch.

-U.S. Smithsonian Institution - Science Information Exchange.

-U.S. Veterans Administration Hospital - Automated Hospital Information System.

-University City Science Center.

-Wyeth Laboratories - Scientific Information Section.

Engineering

-American Petroleum Institute - Central Abstracting and Indexing Service.

-American Society for Metals - Metals Information System.

-John Crerar Library - Research Information Service.

-Engineering Index, Inc. - Information Services.

-Engineering Societies Library.

-Engineers Joint Council.

-Illinois Institute of Technology - IIT Research Institute - Computer Search Center.

-Information Interscience Inc. - Science Information Center.

-North Carolina Board of Science and Technology - Science and Technology Research Center.

-North Carolina State University - D.H. Hill Library - Technical Information Center.

-Nova Scotia Research Foundation - Technical Services Division.

-U.S. Army - Cold Regions Research and Engineering Laboratory - Cold Regions Information System.

-U.S. Army - Corps of Engineers - Office of the Chief of Engineers - Scientific and Technical Information Division.

-U.S. Army - Missile Command - Engineering Documentation Division Documentation Automated Retrieval Equipment.

-U.S. Army - Tank-Automotive Command - Engineering Drawing Depository.

-U.S. Army - Watervliet Arsenal - Technical Information Service Office - Benet Laboratories.

-U.S. Defense Supply Agency - Defense Industrial Supply Center - Technical Document Supply Center.

-U.S. Department of Commerce - National Technical Information Service.

-U.S. Department of the Interior - Department of Reclamation - Information Storage and Retrieval Project.

-U.S. Library of Congress - Science and Technology Division

-U.S. Library of Congress - Science and Technology Division - National Referral Center.

-U.S. National Bureau of Standards - Office of Engineering Standards Services - Information Section.

-U.S. Navy - Naval Postgraduate School - Dudley Knox Library.

-U.S. Navy - Naval Ship Systems Command - Scientific Documentation Division.

-U.S. Patent Office - Office of Search Systems and Documentation Classification System.

-University of Calgary - Information Systems and Services Division.

-University of Nebraska - Nebraska Engineering and Business Services.

-University of New Mexico - Technology Application Center.

- University of Southern California - Western Research Application Center.
- Virginia Polytechnic Institute - Extension Division - Virginia State Technical Services.
- Western Electric Company - Engineering Research Center - Information Science Department.
- Whirlpool Corporation - Information Center.
- Xerox Corporation - Systems and Services for Libraries.

Agriculture

- Monsanto Company - Information Center.
- South Dakota State University - Institute of Irrigation Technology - Information Services.
- U.S. Department of Agriculture - Agricultural Research Service - Information Division.
- U.S. Department of Agriculture - Current Research Information System.
- U.S. Department of Agriculture - Foreign Agricultural Service - Information Service Branch.
- U.S. Department of Agriculture - National Agricultural Library.
- U.S. Department of Agriculture - National Agricultural Library - Agricultural Sciences Information Network.
- U.S. Department of Defense - Defense Supply Agency - Defense Documentation Center.
- University of Miami - Morton Collectanea.

Business

- Conference Board, Inc. - Division of Information Service
- De Soto Inc. Information Center.
- Monsanto Company - Information Center.
- North Carolina State University - D. H. Hill Library - Technical Information Center.
- Oregon Total Information System.
- Predicasts, Inc.
- Southern Methodist University - Industrial Information Services.

-Stanford Research Institute - Long Range Planning Service.

-Stanford University Libraries - Technical Information Service.

-U.S. Department of Commerce - National Technical Information Service.

-University of Minnesota - Walter Library - Technical Information Service.

-University of Nebraska - Nebraska Engineering and Business Services.

-Virginia Polytechnic Institute - Extension Division - Virginia State Technical Services.

Chemical Technology

-American Chemical Society - Chemical Abstracts Service.

-B. F. Goodrich Chemical Company - Technical Information Center.

-Monsanto Company - Information Center.

-Southwest Res. Institute - Information Services and Library.

Metallurgy

-American Society for Metals - Metals Information System.

-Battelle Memorial Institute - Columbus Laboratories - Defense Metals Information Center.

-Belfour Stulen, Inc. - Mechanical Properties Data Center.

-Goodyear Tire and Rubber Company - Goodyear Atomic Corporation - Information and Records.

-Iowa State University - Institute for Atomic Research - Rare-Earth Information Center.

-Lockheed Aircraft Corporation - Lockheed-Georgia Company Scientific and Technical Information Department.

-Lockheed Aircraft Corporation - Lockheed Missiles and Space Company Technical Information Center.

-Reynolds Metals Company - Technical Information Services, Research and Development.

-Tin Research Institute, Inc. - Technical Service Center.

-U.S. Army - Watervliet Arsenal - Technical Information Services.-Office - Benet Laboratories.

-U.S. Bureau of Mines - Albany Metallurgy Research Center - Thermodynamics Laboratory - Contributions to the Data on Theoretical Metallurgy.

Manufactures

- -Nova Scotia Research Foundation - Technical Services Department.
- -RCA Corporation - David Sarnoff Research Center.
- -Southwest Research Institute - Information Services and Library.

Building Materials

- -U.S. General Services Administration - Office of Public Affairs.

III. ANALYSIS OF STICs

The science and technical information centers are analyzed from the viewpoint of output data specification since the concern of the project is with science and technology transfer from these centers into educational institutions. The analysis does not include structual features of the STICs such as configuration, allocation of processes in the system etc. Attention is focused on important parameters of STICs and little attention is given to system processing features.

The mechanization/automation of most of the science information centers is concentrated mainly in the following stages:

-non-selective dissemination of information via bulletins, abstracts, or bibliographics

-selective dissemination of information

-subject selection of articles

The introduction of machines into information processing could yield good results if used simultaneously at all the above three stages in:

-compiling bibliographic listings, indexes, etc.

-selective dissemination of information on the basis of interest profiles

-answering individual request by selecting relevant documents

1. Characteristics of Processed Information

Analysis of the characteristics of processed information leads to a focus mainly on the initiative and responsive output of STICs which are defined in section III.2. Since science and technical information from STICs will be utilized in educational institutions, they are analyzed according to the forms of output that are available from STICs. [Sec. III.3] In Sec. III.5, some of the interactions between the user and the system are discussed.

2. Functional Categorization of Information

As information is manipulated and processed in the system, it undergoes various transformation which make it desirable to re-define the information "packages" by type at various stages of the process. Of the several functional categorizations of information, those categories relevant to the STITE project will be initiative outputs and services and responsive outputs and sources. Less emphasis will be given real-world inputs, system-oriented inputs, and system stores.

2.1 Initative Outputs and Servi[illegible]

One of the main functions of an information service system is to provide effective dissemination of information to the user population. As a result, information may be classified in terms of the types of initiative outputs and services which the system is to provide. This information will assist the educator community in the development of new courses in a subject discipline.

2.2 Responsive Outputs and Services

The other service function of STICs is to provide services in response to user requests. Information may therefore be categorized in terms of the types of responsive outputs and services to be provided by the system. These outputs and services will aid the educator community in updating the teaching materials and modifying for other purposes courses currently offered in educational institutions.

3 Output Data Specification

In the design of the proposed STITE, a specification of the output required by the several user communities is to be made. This may require some of the STICs to do some additional programming work or to modify their existing programs.

The general input information types to STICs are the following:

-composite works (journals, proceedings, etc.)

-monographs (books, monographic series, etc.)

-research and development reports

-secondary publication (abstract journals)

-research - in - progress reports

Initiative output products from these centers for assisting the user/educator communities in developing new courses in a chosen subject area, could be the following:

- announcement lists
- book-form catalog
- research-in-progress index
- biographical index - directory etc.

The responsive output products from these science and technical information centers, in response to user requests, should be of the types that would assist the educator community in updating their teaching materials periodically, thereby enhancing the effectiveness of the teaching systems. These responsive outputs will be the following:

- demand bibliographies
- specific document search
- hard copy retrieval
- state-of-the art report

4. Methodology for the Analysis of Output

Some of the learning/teaching systems may require the outputs from STICs in a particular form, such as slides, videotape, magnetic tape, etc. These requirements are to be analyzed in conjunction with the forms of output that are obtainable from the existing science and technical information centers. It is assumed that a decision will be made at the design stage of the STITE system.concerning whether the particular forms of information materials should be developed at the respective user locations from the outputs the user receives from these centers in whatever form they are available, or whether recommendations should be made to the existing STICs to provide their outputs in the forms desirable to the users with a nominal fee for the cost incurred in preparing them. At this early stage, it seems that the user community will have to prepare its learning materials in the desired forms from the information materials they receive from STICs. These aspects of initiative outputs, as well as the responsive outputs, are yet to be studied in detail, simultaneously with the analysis of the teaching/learning systems.

5. Interactions Between the User and the System

The user/educator community will request science information from STICs and will evaluate the system by the relevance of the material received. To design the proposed STITE system, it will be necessary to consider

-the determination of user requirements

-the interaction between the user/educator community and the system

-the various types of retrieval requests

The user/educator community may conceivably approach these STICs either directly or via an intermediary with a need for modifying or updating teaching materials in a given subject area.

In traditional libraries, the user has many options. He may request help from a reference librarian, he may browse through the open stacks of books, or he may use the card catalog. Although the information center, particularly the automated information storage and retrieval center, is organized differently than the library, it must provide the user with a similar range of capabilities and services. Indeed, because of the high cost of automation, the services provided the user should be more, certainly not less, than those provided by a conventional library. How to allow for maximum interaction between the user and the science and technical information stored in an automated system might be one of the main design problems.

6. User Request Analysis

The different types of user requests and their implications for STITE system design can be summarized as follows:

6.1 Request for a Specific Document or Article - The most frequent request received by an information center is for a specific document or article. In an automated system, the document number from an index file is obtained and then a copy of the document from the microfilm store is retrieved and sent to the user by mail or the content of the document is sent to the user via the existing communication links.

6.2 Requests for Information by Subject - Another common request is for information on a particular topic, such as documents dealing with satellite communication concepts. In most of the existing science and technical information centers, the system response to this form of request is good. Generally the user wants relevant documents but not necessarily all relevant documents, and he wants the material in a reasonable period of time. Most information centers have no difficulty in responding to this request.

6.3 Requests for an Exhaustive Search - Some user might request a state-of-the-art report on a particular topic in a subject area. In fact, some research problems require that the investigator make a systematic and thorough search through all of the literature to determine whether or not the information he needs has been reported elsewhere. These possible needs of the users necessitate analysis of the existing science and technical information centers in their capabilities of handling such users' requests.

Finally users request information to keep abreast of developments in a given field, and there are now several publications devoted to promoting current awareness in specialized areas. (Chemical Titles, for example). Also various selective dissemination procedures attempt to provide information to the specialist before he recognizes his own needs. These services will be analyzed in greater detail at a later point.

7. Summary - The utility of the outputs from STICs for educational systems is an essential consideration for the proposed design of a STITE system. Carroll [Ref. 2], has gathered information from representatives of all known commercially available tape services and lists this information under the following categories:

- -name of tape
- -source
- -contact - representative for further information
- -characteristics of the data base
- -frequency of tape issue
- -average number of source items per tape
- -subscription cost or leasing details
- -software availability
- -type of in-house service offered
- -publications produced from base by originator

A total of 56 services is listed in the Carroll report. Further study on available scientific - technical tape services is being carried on.

From the viewpoint of the objectives of the project, it will be necessary to make a survey of the experience of educators in the utilization of the services provided by science information services. At present educational institutions seem to use the services provided by these centers only in research work, and little utilization is made for the purpose of enhancing the effectiveness of educational tools and materials. Technology utilization by educational institutions in these centers, such as the North Carolina Science and Technology Research Center, Research Triangle Park, N.C., seems to be limited to the area of finding information for graduate students in several universities that are a part of the center. Smetana and Walker [Ref. 15] announce some of the results of "Literature Searches for Theses by Computer". They describe the results of a two year program to provide low cost, computer-performed searches of the NASA literature resource for graduate students. They found that 70% of the participants(users) from all fields were enthusiastic about the program, and most felt that their research improved. Smetana states that the major complaint about the program is the lack of breadth in the NASA information collection, particularly in the chemical area. Smetana also lists the number of searches and their distribution by major field for a period of 2 years, and it is found that graduate students from the field of mechanical engineering have the maximum participation.

From the table, it is clear that most of the STICs offer magnetic tape services. But quite a few centers have magnetic tape services available for their internal use only. Likewise quite a few centers have their microform services available for internal applications only. But most centers offer these services on a subscription basis. Nearly 50% of the centers selected offer a selective dissemination of information service. A large number of centers offer services such as abstracting, indexing, systems analysis etc., and for further details of other services, see Kruzas [Ref. 9].

Almost all centers have hard copy retrieval, and most of the centers are partially automated. The magnetic tape-oriented data bases have primarily abstracts and index catalogs on tapes, and a few centers have the entire text on the data base.

From the above analysis, it is apparent that there are virtually no STICs which give science and technical information in the form of film, movies, videotapes, slides or any other forms that can be readily used in an audio-visual instructional system. From this it can be inferred that the educator community, on getting the information from STICs, will have to transform it to the particular form that is compatible with their mode of presentation in the respective instructional system. Also it can be concluded at this stage of the project that, in addition to hard copy retrieval, magnetic tapes offer a suitable medium for the transfer of science and technical information from STICs to educational institutions.

IV. TABULATION OF OPERATIONAL CHARACTERISTICS OF SELECTED STICS

As is indicated Kruzas [Ref. 9], a large number of centers have restrictions regarding their available services. There are mechanized centers which offer their services only to their employees in their respective companies, and they do not offer any services to the educator community. These centers are not included in the table. However in the subject classification of centers, all the centers are mentioned.

In the table which follows, main operational features of a selected set of STICs are summarized. The initiative outputs and the responsive outputs mentioned in III.2 are given in the table, as well as the existence of any microform services, magnetic tape services, and selective dissemination of information services. Data on microform services include form, size, and conditions of availability of microforms produced or distributed by reporting unit. (Note: In the table if the service is available, an X is placed in that column. For further details of available services, see Kruzas [Ref. 9].) For magnetic tape services, specifications and availability of formalized tape service, as well as locally maintained computerized date bases, is indicated. For descriptions of other in-house computer programs and applications and details of the centers, see Kruzas [Ref. 9].

An X placed in a column by a center indicates that the particular center offers that service. If a column is left blank, it indicates that no information is available or that it is unknown. In responsive outputs under column 2, "Spec. Document Search" is indicated in the table if the search in the center is a manual one.

OUTPUT AND SERVICES OF SELECTED SCIENCE AND TECHNOLOGY
INFORMATION CENTERS

LEGEND:

Initiative Outputs: 1 - Announcement lists; 2 - Book form catalogs; 3 - Res. in progress index; 4 - Biographical index directory.

Responsive Outputs: 1 - Bibliography; 2 - Spec. Document Search; 3 - Hard Copy Retrieval; 4 - State-of-the-Art Reports.

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
1. American Chem. Society	x	x	x	x	x	x	x		Chemical abstracts on 16mm microfilm. Also microcards	x	None	IBM 1401 system; 1402 card reader/punch 1403 or 1404 line printer; IBM 360 OS with 44 K; 2400 series 9 track tape drivers;	Files on microfilm are available on a lease basis, subscriptions are available on an annual basis in most cases	Chemical Abstracts Services (CAS)
2. American Geo. Inst. (AGI) Geological Ref. File	x	x			x	x	x	x		x	x		On a subscription basis	Geology, earth sciences etc.

ience formation nter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
AIAA OTIS)		x				x			x	None		Microfiche readers for microfiche subscribers	None	Aeronautics, astronautics, space sciences etc.
AIP (NISPA) National Info. System for Physics and Astronomy	x	x			x	x	x		x	x	None		Tape Services available on a lease basis	Physic and Astronomy (Abstracting and Indexing services available)
American Library Assoc. (ALA) & Info. Science & Automation Div.	x	x					x	x	None	None	None		Services available to members of ALA only	Automation of Library technical service operation tele communication the computer in library information operations;
American Mathematical Society (AMS)		x	x		x	x	x		None	x	x		By subscription to individual Mathematicians or to groups, but no institutional subscriptions are permitted	Pure and applied math.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
. AMA (American Medical Assoc.)	x	x	x		x	x	x	x	x	None	x		To AMA members, mecical librarians and other authorized individuals only	Medicine; sociological and economic aspects of medicina
. American Petro.		x	x			x	x		(16 mm reel of the abstract)	x	x	Tape units compatible to IBM equipment.	On a subscription basis only	Chemistry engg. & technology perinent to petroleum refining and petro chemical industry.
. American Society for Metals (ASM) Metals Inf.Sys. (MIS)	x	x			x	x	x	x	x (for interntial use only)	x	x	Depending upon service used.	No restrictions	Materials science, metals and metallurgy. [All computer processing for ASM is done by service Bureaus]
0. American Society Hosp. Pharmacists (ASHP) (International Pharmacential Abstracts) IPA	x		x			x	x		x	x	None		No restrictions	Pharmacential technology

ce rmation er	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
Ampex Corp. (Technical Information Services)	x	x				x	x	x	None	None	x	None (By mail or by phone)	Inter-library loan available to outside organizations; other services available to	Magnetic Recording, computer technology and
Atomics International Liquid Metals (LMIC)						x	x	x	None	None	x	By mail or phone	None for U.S. residents	Liquid metals technology
. BMI (Columbus Laboratories)						x	x		None	x	x	Teletype units of CDC compatible display	Services limited to their subscriptions to their basis-70 system.	Plastic material defense metals Battery inf.; Cobolt, high temp. alloys; fiber technology; copper technology, other metals etc; effects.

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
14. Becker & Hayes Inc.	x	x				x	x	x			x	By phone or by mail	Services available or on costrub.	Inf. science: networks & communications micrographics; electronic data processing and comp. sciences.
15. Belfour Stulen, Inc. (Mech. Properties Data Center - MPDC)	x	x	x			x	x	x		x		By phone or by mail	Services available for a fee	Metals and their alloys including mechanical & structural properties
16. Biosciences Inf.Service of Biological Abstracts (BIOSIS)	x	x	x	x		x	x	x	x	x	x	For BA previous user needs IBM 360 computer using 9-track 800 BPI tapes	Subscription or lease services available to all.	Research Literature in Biological science.
17. Brigham Young Univ.- High Pr. Data			x		x	x	x	x	None	None		By mail or by phone.	To anyone interested in high pressure research.	Pressure calibration in the range of 10-300 kilokars etc. Makes use of IBM 360/50 at the Univ.

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
18. Center for Applied Linquistics (CAL)	x	x			x	x	x	x	x		x	By mail or by phone	No restrictions	Linguistics; (It is also a part of the ERIC of the U.S. Office of education).
19. Chemical Harizons, Inc. (Chemical Intelligence file-CHIF)	x	x							x	x	x	By mail or by phone	No restrictions	Commercial chemical developments & all market statistics.
20. Chemical Systems, Inc. (Computerized Structural Group Index of Com.Org. Chemicals)					x	x	x	x	None	x		UCC can interface with Cope series, Univac 1004/1005,Univac 9200/9300, IBM 1130/360/20, 360/30, and CDC 200 user terminals.	Users must enroll with chemical systems to retrieve data	Chemical systems utilizes computing company facilities in LA, Dallas, NY, & Zurich

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
21. CIBA Pharmacential Co. Scientific Inf. Center	x	x	x		x	x	x		x	x		By mail or by phone	No restrictions to personnel	Chemistry pharmacology; microbiology; pharmacy & Clinical medicine.
22. Climax Molylodenum Co.- Tech. Inf. Center	x	x			x	x			None	None		By mail or by phone	Services available without restrictions but center is not open to the public.	(Manual literature searching) metallurgy & chemistry of nolylodenum,
23. College of Physicians -Medical d Services (MDS)	x	x				x			None	x	x	By mail or by phone	Services provided to those undertaking research in biomedical fields	Biomedicine and fields.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
4. Computting & Software, Inc. Derivation & Tabulation, Assoc., Inc. (DATA)	x	x						x	x	x	None	For Mag.Tape needs computer with 9 track 800 BPI using Cobol	Avail able by subscription Tapes are on a rental basis.	Technical compo. such as transitors diodes, integrated circuits & relays. Also data concerning compo. can be tabulated
5. John Crerar Library -Research Inf. Services (RIS)		x				x	x			x		By mail or by phone	No restrictions	All areas of pure & applied science including technology and medicine;
6. Dittberner Assoc. -Project Master		x					x	x		x		Preferred that Customers use Project Master's	Services available on a contract basis	Data Communication including future data comm. applications, digital transmission systems computer controlled

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
27. Dow Chemical Co. - Joint Army-Navy-Air Force Thermo Chemical Tables (JANAF)	x											Mag.Tapes are in IBM BCL, easily processed on such IBM equipment as 7090 or 360/30 computer	To qualified users on a fee basis;	Heat capacity, entholphy, entropy, full energy function, heats and full energies of formation for components of the elements H,Li, Be,B,C., etc.
28. Excerpta Medica Inf Sys.Inc Automated Storage & Retrieval System of Drug Literature	x	x	x		x	x	x		x	x	x	By phone or by mail	None	Medical and Chemical data on dryes and chemical compon
29. Franklin Inst. Research Lab.- Inst. for development of Riverine & Estuarine Sys. (IDRES) & Science Inf. Services(SIS) Dept	x				x	x	x	x	None	None	None	By phone or by mail	None	Biological chemical engg, ecological aspects of riverine-estuarine use and all areas of physical, biochemical & environ mental

Science Information Center	Initiative Outputs 1	Initiative Outputs 2	Initiative Outputs 3	Initiative Outputs 4	Responsive Outputs 1	Responsive Outputs 2	Responsive Outputs 3	Responsive Outputs 4	Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
30. General Dynamics Corp.-Convair Aerospace Div. Lib. & Inf. Services	x	x				x	x		x	x	x		Only inter-lib. loan to outsiders	Aerospace electronics, life sciences & gensciences etc.
1. General Tele. & Electronics labs. - Tech. Inf. Prog.			x		x	x			x	x	x	None	Conditions of service are available upon request	Communications, electronics system analysis; network synthesis; logic design & other aspects of inf. transfer
2. George Washington Univ. Dept. of media & public affairs (BSCP)	x	x	x	x	x	x	x	x				None	No restrictions	Information, education & practical trg in communication concerning the life sciences.
. Honeywell Inf. Systems, Inc. (HISI)-Inform. Services Operations (ISO)									None	x		Flexible	No restrictions	Variable according to customer's desires and needs.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
4. Hughes Aircraft Co. -EPIC-	x		x			x	x	x		x		None	Limited to gov. agencies their Contractors & those in a position to assist in the defense effort.	Electronics properties Inf.Center (EPIC)
. IIT Research Inst. (IITRI) - CSC-						x			x	x	x	None - can be used on any IBM 360 model 40 up	Services are purchased on a subsciption or contract basis	Data bases in chemistry and Biology
. Indiana Univ.- Aerospace Research Appl. Center						x			x	(no inf.)	x	None	To member companies only - on a fee basis	Part of NASA regional dissemination center network. (Applications of aerospace science & technology.
. Inst. for Scientific Info. (ISI) Phil., Penn.			x	x	x	x			None	x	x	Tape subcribers package can be easily modified for larger modds of IBM system 3600 or adapted computer of other Manu.	To subscribers only.	Life sciences; physical & chemical science agricultural food & vetering sciences; engg & to

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
8. IEEE Inf. Services Dept.	x		x			x	x		x	x		None	Tape services or a yearly Contract no restrictions for other services	Electrical and electronic Engg.
9. Inst. of Paper Chemistry -ETIC-						x	x	x		x	x	Most inf. requests are serviced offline through the mail or by phone.	None	Environmental aspects of the pulp and paper industry.
0. Inst.of Textile Technology-Textile Inf.	x	x				x	x			x		Center's system maybe duplicated using an IBM 1130 computer subscribers may use mag. tapes;	None	All aspects of Textile technology (Tapes are written in a Burroughs code or language).
1. Interdok Corp. N.Y.					x	x	x			x			None	Conference proceedings in the fields of engg. science, medicine, & technology. (Interdok shares time on IBM 360).

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
42. Iowa State Univ. -Rare Earth Inf. Center (RIC)	x	x				x	x	x	None	None		None	None	Physical metallurgy and solid state physics of the rare earth metals their alloys.
43. Johns Hopkins Univ. -Applied Physics Lab -(CPIA)	x	x				x	x	x		x			Registration with U.S Defense Documentation Center with confidential facility clearance	Solid and liquid
44. Lockheed Aircraft Corp. - Ga. (SCI-TECH)	x					x	x	x	x	x	x		No Inf.	Aerospace technology nuclear science, OR, electrons, propulsion, metallurgy, computers etc.
45. Monsanto Co. Inf. Center -Mo.	x	x		x		x	x	x	x	x	x		Outsiders may make arrangements to use their lab.during office hrs.	Chemical business agriculture biology engg. plastics textile etc.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
6. N.C. Board of Science & Technology (STRE) - Research triangle park N.C.			x			x	x	x	x	x	x	By phone or by mail	Services available to users in the South Eastern section of U.S. with some exceptions.	All fields of Science and Engg.
7. Ocean Engg Inf. Service	x					x	x	x			x	By phone or by mail	None	Oceanography and ocean engg.
8. Ohio State Univ. Libraries - Mechanized Inf. center (MIC)						x				x (Internal application only)	x		Services available to those applicated with Ohio State University.	Physical Sciences engg. and life Sciences
9. Oklahoma State Dept of Libraries - MARC Services	x					x	x		None	x	x	Subscribing Libraries need a computer with 9 - level 800 BPI tape drive	On a fee basis.	All subjects of interest to subscribers

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
50. U.S. Air Force (Aerospace materials Inf. Center) -AMIC	x	x				x	x		x	x (for internal use only)	x		Restrictions on classified materials	Adhesives, coatings, lubricants fibrous materials, metals, ceramics etc.
51. U.S. Army Material command (STINFO) Washington D.C.						x	x		x	x	x		Services restricted to U.S. Dept. of Defense agencies and then contractors.	Physics, electronics engg, chemistery, mathemetics etc.
52. U.S. Atomic Energy Commission (Ames Laboratory), Ames, Iowa.									None	x	x (only service)	IBM 360/40 and up.		General Science and technology
53. U.S. Atomic Energy commission Division of Technica; Inf. Extn. (DTIE) -Nuclear Science Abstracts	x	x				x	x		None	x		IBM 360/67, Univac 1108, CDC 6600, IBM 360/65, CDC 7600, IBM 7094 IBM 360/40	To any Subscriber	Nuclear Science and Technology

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
54. U.S. Atomic Energy Commission -ORNL- -Atomic & Moleuler processes Inf. center Oakridg Tenn.					x	x	x	x					Services are availabl to Govt. agencies research and educational institutions and industry.	Heavy particle - heavy particals interactions; particle interactions with electric and megnetic fields etc.
55. U.S. Atomic Energy Commission -ORNL -CTC Oakridg Tenn.					x	x	x			x	x		Under th provisions of the CENTERS contract only	All aspects of nuclear Science and technology
56. U.S. Atomic Energy Commission -ORNL -Isotopes Inf. cen ter (IIC)	x	x						x	x	x			No restrictions	Isotopes and Radiation Technology

cience nformation enter	Initiative Outputs				Responsive Cutputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
7. U.S. Bureau of Mines Albany Metallurgy Res. Center Thermo lab. Albany, Oregon	x					x	x	x			None		None	Metallurgy and ceramics
8. U.S. Bureau of Mines Division of Field operations Alaska Field operation center	x					x	x	x	x	x (Internal applications only)	None			Geology Mining Engg., economics and gen. Science
. U.S. Dept of Agriculture CRIS-	x		x						None	x (Not available to outside users)	None		Only to Scientists and research managers of U.S. Dept of Agriculture.	Agriculture

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
0. U.S. Dept of Agriculture -National Agri Library	x				x	x	x		x	x		IBM 360/40 with 6 tape devices, card reader and printer	None	Agriculture
1. U.S. Dept of Defense -Defense Supply Agency -(DDC).	x	x				x	x	x	x	x	x	Computers which can accommodate IBM mag. tapes.	Services available to U.S. Govt. organization, their contractors, and grantees.	Aeronautics, agriculture, astronomy astrophysics, atmospheric Sciences, earth Sciences, and all fields of engg and technology.
2. U.S. Environmental Protection Agency Air Pollution control office) -OTIP -APTIC res triangle Park, N.C.	x	x			x			x	x	x (For internal applications oonly)			Free Services to official personnel only abstracts of all literature on APTIC are available on request.	Air pollution effects, atmospheric interactions etc.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
3. U.S. NASA Manned spacecraft center -Technical library, Houston, Texas.	x	x				x	x		x	x	x		Services limited to NASA personnel only	Engg. aspects of space vehicles including life support systems human engg etc.
4. U.S. NASA (NSS DC) Greenbalt, Md.	x	x	x		x				x	x		Variable, depending on request	Services available to all engaged in legitimate Scientific research.	Scientific experiments from Satellites, space probes, rockets, balloons, and high alk-aircraft.
5. U.S. NASA scientific and Technical Inf. office, Washington, D.C.	x	x	x			x	x	x	x	x	x	By phone or by mail	Limited to NASA associated organizations, contractors and grantees	World - Wide aerospace information

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
66. U. S. National Bureau of standards -Cryogenic data center Boulder, Colorado	x	x			x	x	x	x	x	x	x		To all members of the techinical community.	Thermo physical posperties of fluids and solids for cryogenic use.
67. U.S. National Bureau o of Stds. -Office of Engg stds services Gaithersbury, Maryland.	x	x				x			None	None	x		None	Engg. stds, specifications and test methods etc.
68. U.S. National library of medicine Bethesda, Maryland.	x	x			x	x	x		x	x	x		None	Medicine

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
69. U.S. N.L.M. -MEDLARS Bethesda, Mary-Land					x	x	x			x	x		To health-science practitioners, educators, researches and students	Medicine
70. U.S. National Oceanic and Atmospheric Admin. -National ocean survey Detroit, Mich.						x		x	x	None	x			Hydrographic surveys, charts and cartography, water lands, hydrology etc.
71. U.S. Natl. Oceanic & Atmo. Admin Scientific Inf. and Fourmentation Division Rock-ville, Mary-land	x	x				x	x		None	None	x		None	Oceanography, Marine biology etc.

nformation enter	Initiative Outputs 1	2	3	4	Responsive Outputs 1	2	3	4	Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
2. U.S. NSF -OSIS Washington, D.C.	x	x	x				x		None	None	None		None	Scientific and technical info., including storage and retrieval lingeristics etc. (Referral service only)
3. U.S. office of Education -ERIC clearing house on Educational media & Technology Stanford, California	x					x	x	x	x	x	x		None	Educational Media and Technology, such as instructional films, television, prog. instruction, CAI, etc.
74. U.S. office of Education -ERIC clearing house relinguistics Washington, D.C	x					x	x	x	x	x	x		None	Linguistics

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
5. U.S. office of Educ. -ERIC clearinghouse for Science & Math-Education (ERIC/SMAC)	x				x	x	x		x	x			None	Science and Mathematics.
6. U.S. Public Health Service -Bureau of Radiological Health (BRH) -DSMS.	x								None	x	None		Services are available to all within the U.S. Bureau of Radiological Health within restrictions.	System analysis and design, and computer programming in the fields of medical education.
7. U. S. Public Health Service Natl. Institutes of Health Natl. Cancer Inst. CENSC -PRA	x	x	x			x	x		x	x	x	IBM 360 Compatible magnetic tape	Scientists & physicians involved in related research	Cancer Chemotherapy.

ience formation nter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
. U.S. Smithsonian Institution -SIE.						x	x		x	x	x		None	Life, Physical and social sciences including medicine agriculture, education etc.
. Unv. Microfilms, Ann Arbor, Michigan						x			x	x' (for Internal use only)			Services available on a fee-basis.	All Do toral dissertations.
. Univ. of Arkansas Medical Center -Dept of Radiology -DRIS.						x			None	x (for inter-applications only)			None	Diagnostic Radiology (Systems analysis and Design and antomatic indepiray services are also applicable)
. Univ. of of Calif. -Lawrence Radiation lab. -Biomedical Div.	x					x	x	x		x (Internal applications only)			U.S. Govt. agencies and their contractors	Source, transport, and interaction of radionuclides with the biosphere etc.

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
82. Univ. of Calif Berkeley -LRL -Inf. Research Group (IRG)						x			x	x	x		Outside users conditionally recepted	Biology, chemistry, engg, geology, math & computers, metallurgy, Physic, etc.
83. Univ. of Calif. Los Angels -school of Medicine & Bio-medical Library -Brain Inf. Service (BIS)	x	x	x		x	x	x	x		x (Internal applications only)	None		Services are limited to research scientists & clinicians in basic neurological sciences	Newroanatomy, newrophysislogy, newrochemistry, newropharmacology
84. Univ. of Colorado -JILA		x			x				x	x (but no outside service)			None	Low energy electron collision cross-sections; photoabsurpsion cross-section; election swarns; ion-molecule reaction rate data etc.

ience formation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
5. Univ. of Connecticut New England Res. App. Center (NERAC)		x				x	x	x		x (Internal use only)	x		No restrictions to business industry and Govt organizations.	Principals fields involve research and development results of Govt. and private activities & their application in industries etc.
6. Univ. of Dayton Res. Inst. (UDRI) Aerospace Materials Inf. Center Dayton, Ohio	x				x	x	x	x	x	x (Internal use only)	x		Retrospective searches are conducted without charge for U.S. Govt. and private industry users concerned with Dept of Defense efforts.	Aerospace materials of a non-biological nature.
87. Univ. of Iowa -IDIS College of Pharmacy	x					x			x	x	x	File unit to hold tab size microfiche & index cards & a microfiche reader	Services available on a subscription basis.	Drugs and Drug Therapy.

cience nformation enter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
8. Univ. of Miami -Morton Collectanee		x				x	x	x	None	None			Services are available to professional researchers.	All aspects of economic botamy.
9. Univ. of New Mexico -Technology Application Center (TAC)		x				x	x	x	x	x	x		Services are available to subscribers only	Science, Engg., and Technology (Center is part of NASA's Regional Division -nation centers)
90. Univ. of Notre-dame Radiation Lab -RCDC	x					x			None	x (Internal applications only)			Available to scientists in Radiation chemistry	Radiation, chemistry
91, Univ. of Pittsburgh knowledge Availability system center (KASC)	x					x	x	x	x		x		By subscription.	All aspects of science and Technology (Center is part of NASA's Regional Dissemination centers)

ience formation nter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
. Univ. of Rochester Dept. of Pharmacology -CTCP	x	x								x			Major publications available through purchase	Toxicology of commercial products; diagnosis and treatment of emergency poisionings; (Data collection and analysis).
. Univ. of Southern Calif. -WESRAC.						x	x	x	x	x	x	None	None	Aerospace science and technology; biological and physical sciences, and engg; (It is part of NASA's Regional Dissemination centers).
. Univ of Tulsa -Inf. Services Dept. Tulsa, Oklahoma	x	x	x			x	x	x	x	x		IBM 360/30 computer or larger compatible model for use of tapes.	To subscribing companies only.	Petroleum technology, geology, geochemistry, geophysics, etc.

cience formation nter	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
5. Western Electric Company -Engg Research Center Inf. Science Dept.	x	x				x	x	x	x	x (No external services)	x		Only inter-library loan arrangements are available to outsiders. SDI services are available to Bell System employees only.	Applied Math, Computer Technology.
6. Wolf Research and development corp.									None	x			Services available to Government & industry on a contract basis.	All areas of space sciences. (Reference science mainly)
7. World Data Center-A Coordination office Washington D.C.		x						x	x	x			None	Geomagnetism, seirmology, gravity, meteorology, radiation, oceanography; Rockets and satellites etc.

Science Information Center	Initiative Outputs				Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services	SDI Services	User Equip. Requirements	User Restrictions	Other Remarks (Subject Coverage etc.)
	1	2	3	4	1	2	3	4						
98. Wyeth Labora-Scientific Inf. Section Philadelphia	x	x				x	x	x	x	x x	x			Medicine, pharmacenticals, chemistry, pharmacology biochemistry etc.
99. Xerox corp. -Central Inf. center New York.	x	x				x			x	x (Internal applications only)			By Appointments	Behavioral sciences, chemisty comp. Sciences, electionics, math, photography etc.

V REFERENCES

1. Barks, H. The Analysis & Design of Information Systems. Santa Monica. Calif., System Development Corporation, 1966. 22 pp.

2. Carroll, K. Survey of Scientific - Technical Tape Services. American Institute of Physics September 1970.

3. Cohan, Leonard, ed., Directory of Computerized Information in Science and Technology. New York, Science Associates/International Inc., 1968.

4. Doctors, Samuel I. The Role of Federal Agencies in Technology Transfer. Cambridge, Mass., M.I.T. Press 1969. 230 pp.

5. Doctors, Samuel I., "The NASA Technology Transfer Program - An Evauation of the Dissemination System." New York, Praeger Publishers, 1971. 226 pp.

6. Gehl, John M., and V. Slamecka, A Profile of Scientific - Technical Tape Information Services. Atlanta, Georgia, Georgia Institute of Technology (School of Information and Computer Science). Report.

7. Gruber, William H. and Donald G. Marquis. Factors in the Transfer of Technology. Cambridge, Mass., The M.I.T. Press, 1969. 289 p.

8. Herner, Saul. A Brief Guide to Sources of Scientific and Technical Information. Washington, D.C. Information Resources Press, 1970. 102 pp.

9. Kruzas, Anthony T. ed. Encycolopedia of Information Systems and Services. Ann Arbor, Mich., Edwards Brothers, 1971. 1109 pp.

10. Kruzas, Anthony T. Directory of Special Libraries and Information Centers. Vol. 1. Detroit, Michigan, Gale Research Company, 1968. 1048 pp

11. Lesher, Richard L. and George Howick. Accessing Technology Transfer. NASA SP-5067, 1966. 121 pp.

12. North American Aviation, Inc. Analysis of Scientific and Technical Information Requirements of FAA. Clearinghouse for Federal Scientific and Technical Information, 1965. AD 651 926.

13. Palmer, Archie M. Research Centers Directory. Detroit, Mich., Gale Research Co., 1972. 1033 pp.

14. Sparks, David E., A Methodology for the Analysis of Information Systems. Wakefield, Mass., Dynamics Corp., 1965. PP 168 264.

15. Smetana, F.O., and Walker S.R. "Literature Searches for Theses By Computer - Results of the First Two Years of the Program." Proceedings of the American Society for Information Science, 6:95-100 (1969).

16. Toman, J. "Information Systems: Stages, Methods, Levels." In Mikherlov, A.I., A.I. Chernyi, and R.S. Bilyarerskii, eds., International Forum on Information. VINITI, Moscow, 1969. p. 190-202

17. U.S. Library of Congress. Science and Technology Div. National Referral Center. Directory of Information Resources in the U.S. Government Printing Office, Washington, D. C., 1971. 803 pp.

VI. Conclusions

Currently the utility of the outputs from science information services for educational systems is being studied. Carroll has gathered information from representatives of all known commercially available tape services [Ref. 2], and he lists the information under the following categories:

Name of Tape
Source
Contact - Representative for further information
Characteristics of the data base
Frequency of tape issue
Average number of source items per tape
Subscription cost or leasing details
Software availability
Type of in-house service offered
Publications produced from base by originator

A total of 56 services is listed in the Carroll report. Further study on available scientific - technical tape services is being carried on.

From the viewpoint of the objectives of the STITE project, it will be necessary to make a survey of the experience of educators in the utilization of the services provided by science information services. At present educational institutions use the services provided by these centers only in their research work, and little utilization is made for the purpose of enhancing the effectiveness of educational tools and materials. Technology utilization by educational institutions in these centers, such as North Carolina Science and Technology Research Center, Research Triangle Park, N.C., is reported to be in the area of finding information for graduate students in several universities.

In the Proceedings of the American Society for Information Science, vol. 6, [Ref. 15], Smetana and Walker announce some of the results of "Literature Searches for Theses by Computer". They describe the results of a two year program to provide low cost, computer-performed searches of the NASA literature resource for graduate students. They found that 70% of the participants (users) from all fields were enthusiastic about the program, and most felt that their research improved. Smetana states that the major complaint with the program is the lack of breadth in NASA information collection, particularly in the chemical area. Smetana also lists the number of searches and the distribution of searches by major field made in 2 years, and graduate students from the field of mechanical engineering had the maximum participation.

The main interest of the STITE at this stage is to analyze the outputs from existing centers and to investigate ways in which present educational systems can benefit by these outputs, assuming that there is a mechanism available for speedy efficient transfer. The goal of the project is to devise such a mechanism, and further research will be directed towards designing such a transfer mechanism and testing it in the experimental phase.

PART THREE

DESCRIPTION OF LEARNING INFORMATION SYSTEMS

PART THREE

DESCRIPTION OF LEARNING INFORMATION SYSTEMS

I. INTRODUCTION

During the past fifteen years or so there has been an increasing volume of research which is seeking to improve the quality of academic level instruction, and to increase the productivity and influence of teachers through the development and organization of instructional materials and subject matter, and the use of various instructional media. During the same period many new communication tools have been developed and are available for use. The motivation for this research on teaching and learning has come in part from the rapid growth in population and from a predicted and actual lack of good teachers. This growing concern to improve learning is also due to the great expansion of new information and to the rapid antiquation of much previously learned knowledge as the result of technological change.

A major task in the STITE project is to obtain a pragmatic understanding of the process employed by science educators in developing and structuring science learning materials. The major component of the strategy used to tackle this task will be a descriptive analysis of the existing learning systems through the following sequence of actions.

1. Investigation of the "Socratic" situation in the teaching-learning process.

2. Analysis of the process of developing materials (course preparation, course development).

3. Description and design of programmed instructional materials.

4. Analysis of computer assisted instruction.

5. Analysis of audio-visual techniques.

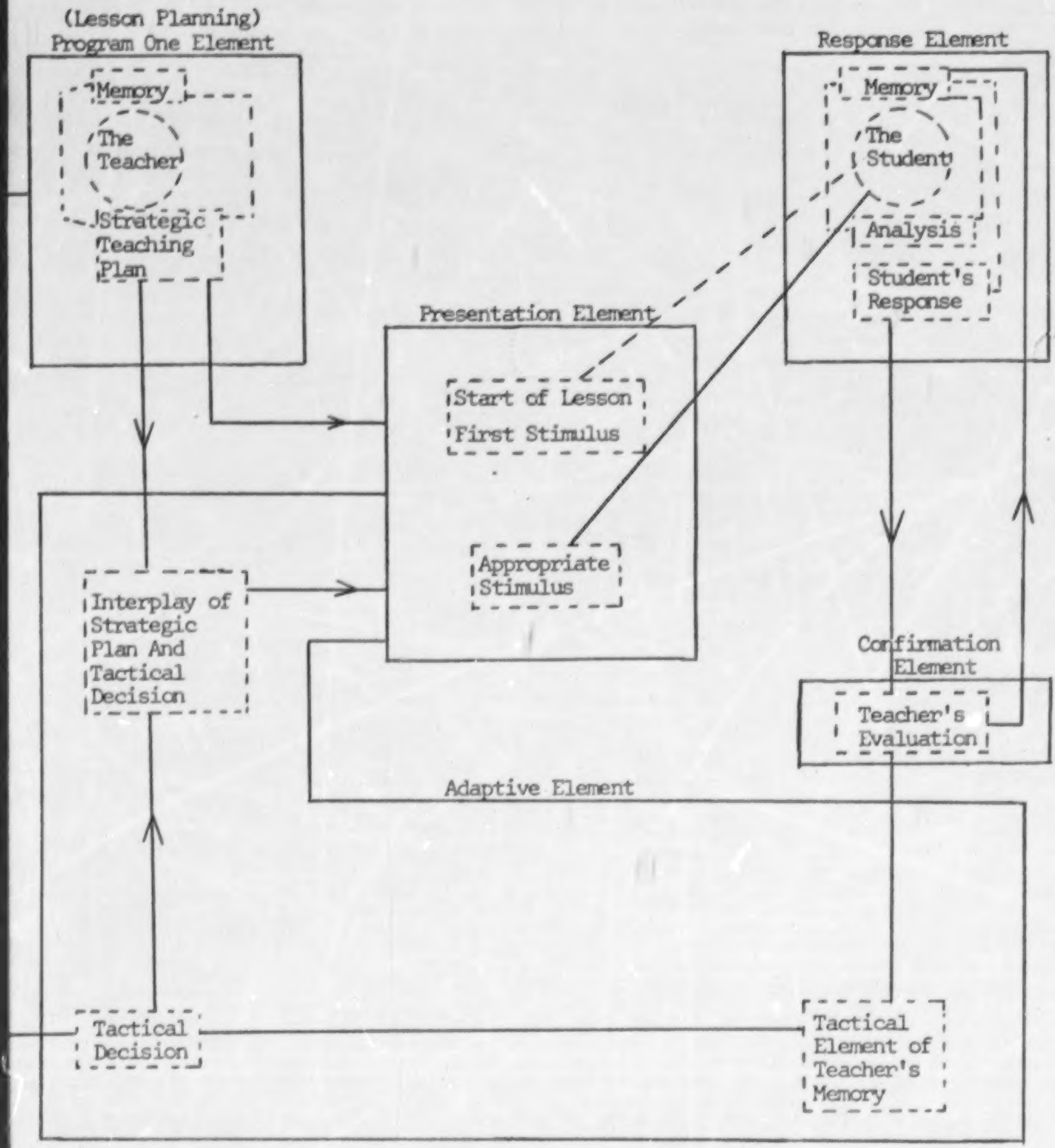

(Lesson Planning)
Program One Element
Memory
The Teacher
Strategic Teaching Plan
Response Element
Memory
The Student
Analysis
Student's Response
Presentation Element
Start of Lesson
First Stimulus
Appropriate Stimulus
Interplay of Strategic Plan And Tactical Decision
Confirmation Element
Teacher's Evaluation
Adaptive Element
Tactical Decision
Tactical Element of Teacher's Memory

Fig. 4

The teacher starts his lesson by presenting a stimulus to the student which will provide sufficient challenge. This will cause the student to call on his memory and his capacity for analysis, and so evoke an overt response. This response is fed back to the student's memory for future reference and serves as a form of partial reinforcement. At the same time, this should be noted and evaluated by the teacher who informs the student whether he is right or wrong, thereby providing additional reinforcement.

After this evaluation, the teacher must consider the next step in the presentation of the lesson. Calling upon his previous experience of teaching the subject, he may decide to change his original teaching plan because of the nature of the student's response, i.e., he makes a tactical decision which he relates to his strategic plan and which produces the modified second stimulus. This appropriate stimulus is presented to the student and the cycle is repeated. The teacher should note in his own memory the subject.

This simple analysis, leads to an investigation of a more general concept, that of course development. It should be noted that if a teacher has a number of students in his class it will be virtually impossible for him to arrive at tactical decisions which will satisfy the needs of each and every student, for the situation of one student - one teacher rarely exists in normal classrooms. This leads to an investigation of the various techniques that are devised to improve the settings with larger groups and subsequently to analyze the various teaching devices that have been designed to improve the learning process.

III. THE PROCESS OF DEVELOPING SCIENCE LEARNING MATERIALS

1. Course Preparation

The most appropriate unit of science learning materials is the course. Several attempts to define the "course" have been made: M. Eraut [Ref.4],for example, defines it as "a separately time-tabled or separately assessed teaching-learning unit occupying from one-half to one-quarter of a student's time over one, two or three terms." Others define it as a set of units where a unit is an integrated part of information which can be studied and assimilated by the learner over night.

The STITE project approach will be to consider the course as a system in which students, teachers, and learning materials interact and to define the course development as a process of optimization of the system.

Before analyzing the system, mention should be made of the most common learning "experiences" that are used in course planning:

1.1 Materials:

- textbooks
- supplemental required or optional readings
- current periodicals
- syllabi
- slides
- films
- tapes
- recordings
- television
- programmed materials
- computer assisted instructions

1.2 Instructional Methods:

- lectures
- discussions
- demonstrations
- problems
- individual conferences
- seminars
- guest speakers
- telephone interviews

1.3 Assignments:

- readings
- problems
- papers
- oral reports

1.4 Activities:

- laboratory
- field trips
- observation
- internships
- work experience
- travel
- public lectures

1.5 Evaluation Methods:

- objective tests
- essays
- papers
- reports
- participation
- self-evaluation

Obviously no one course of the common three-to five-credit variety extending over one quarter or one semester can effectively employ all the preceding elements. Moreover, the choice of experiences made by the instructor is often related to his own activities and ideas rather than to the objectives of the course. Thus as far as "course preparation" is concerned there is not a systematic way to analyse it and to devise a prototype; all that can be gained is some insight into the teaching-learning process.

2. Course Development

In considering the course as a system and in defining the course development as an optimization process, a natural question arises here: what is to be optimized? The answer will constitute the prupose of the present section. The system being considered is an input-output system with a very complicated functional relation from input to output. Specifically three types of input can be defined.

2.1 The student input defined as a set of definite characteristics in terms of knowledge, abilities, and attitudes.

2.2 The teacher input defined as a set of definite characteristics in terms of knowledge, abilities, experience and record.

2.3 The material input defined as a set of constraints or conditions on the expenditure and level of learning material.

Clearly, none of these factors is likely to be totally predetermined. There is usually some scope of adjustment, and the implication of this is that any attempt to define the functional relation which exists from input to output in an input-output system will fail.

The output shall be primarily what students can do at the end of the course.

It should be noted that the question of optimization is relative in the sense that there are usually a number of alternatives: one may aim to improve effectiveness by improving the student's performance at the end of the course; one may aim to improve quality by raising the level of the objectives of the course; or one can improve efficiency by reducing costs and maintaining the same output. The best policy is usually to set general guidelines for optimization at the beginning and to choose the appropriate attributes according to the final objectives of the course (without underestimating the requirements of the following course when applicable). Moreover, assuming that an appropriate plan of action has produced a version of a course, the next step would naturally be to evaluate and feed the information obtained from tryouts into a revision process. Consequently evaluation procedures must be used. There are several evaluation procedures, among which are the formative evaluation [Ref. 10], and the summative evaluation. In for formative evaluation the emphasis is on obtaining the kind of information which leads to improvements in the quality of the final version of the course, while in the summative evaluation the emphasis is on totals and counts. In other words, one is more interested in the reason why a student failed to grasp a concept than in precisely how many students failed to grasp it.

3. The Design Process

The following flowchart summarizes the main stages of the course design process:

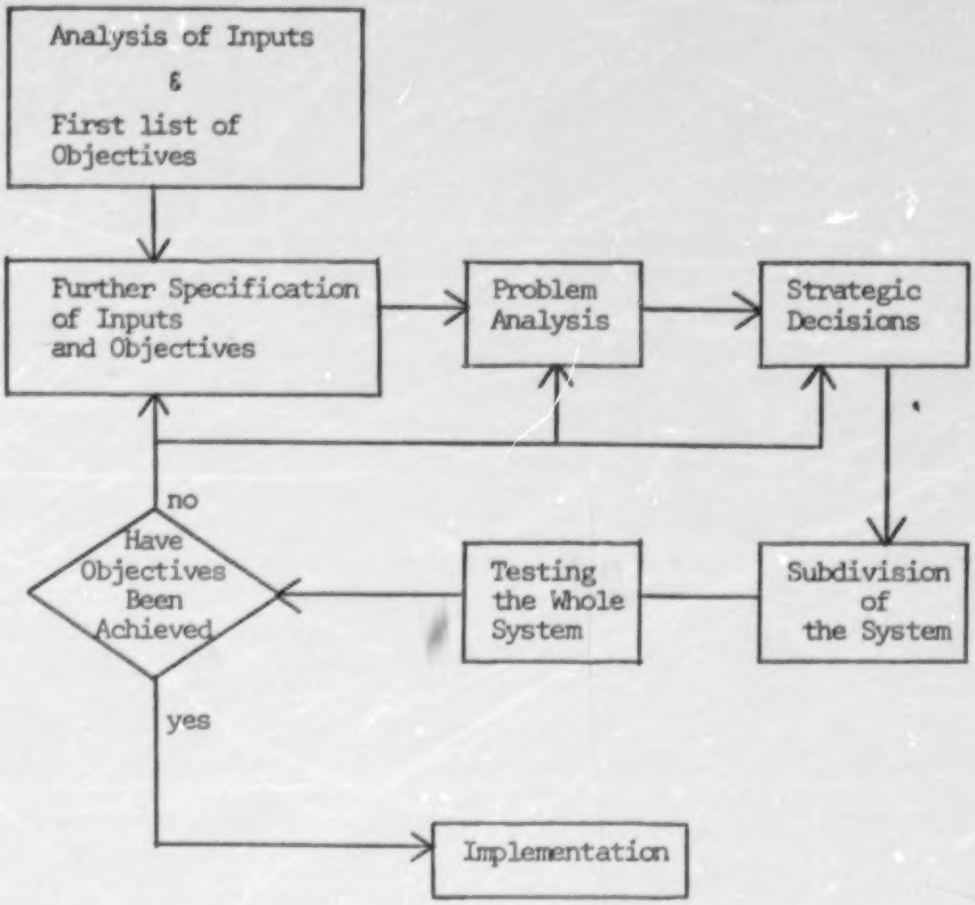

Analysis of Inputs
&
First list of Objectives
Further Specification of Inputs and Objectives
Problem Analysis
Strategic Decisions
no
Have Objectives Been Achieved
Testing the Whole System
Subdivision of the System
yes
Implementation

Fig. 5

A beginning is made by investigating the inputs (the student input and the course input) and by specifying the intended outcomes of the course and what is to be optimized. Then a process of evaluation is selected and the one used will be the formative evaluation for at least some parts of the course. This commitment to formative evaluation is necessary for the development and improvement of the course.

Now that the system is completely defined, the objectives of the course, are specified, an appropriate set of methods of assessment is selected,and a more precise analysis of the student input is made. Some testing of students to see what knowledge and abilities they bring to the course may be necessary. The the main teaching problems in a course are defined, and an estimate about which areas of the course are likely to cause the greatest difficulty is projected.

Following this problem analysis, some strategic decisions have to be made. The course should be subdivided into parts with a definition of the intended outcome of each part. Broad decisions about the type of experience to be used in each part of the course must be made, and these decisions obviously depend on the nature of the course, on the institution where it is offered, and on the facilities available.

Now the previous precedure is applied to each part. Finally the whole course is assembled, tried as a whole, and implemented if the tryout is satisfactory. If the tryout is unsatisfactory, the process may be repeated. (Clearly the cost factor plays as important role).

3.1 Further Specification of Inputs - At the academic level, not all students entering a course will have the same capabilities and the same background. For some courses this is not significant, but for others a precise knowledge of student input is sometimes necessary to obtain the appropriate evidence. It is particularly important in this context to avoid making the usual assumption that all students should be required to go through all the course. Fitting a course to the average student can sometimes lead to disaster: the below-average student may be baffled and the above-average student may be bored. It may, however, be necessary to maintain a minimum entry standard for a course, and this is one possible reason for instituting a pretest.

3.2 Further Specification of Objectives - This is a very critical phase of course development. It can be devided into three stages according to the three levels of objectives outlined by Scriven [Ref. 10]:

- the conceptual level: the level at which discussions of breadth versus depth and knowledge versus comprehension are carried out and the structure of the course is outlined.

- the manifestational level: concerned with ways in which a student's achievement of an objective can be demonstrated.

- the operational level: defines an objective in terms of the precise means by which it is to be assessed. Objectives at this level are called "behavioural objectives" because ultimately objectives can only be assessed by observing some aspect of a student's behaviour. According to Mager [Ref. 7], the characteristics of a behavioural objective are as follows:

  a. Specification of the kind of behaviour which will be accepted as evidence that the learner has achieved the objective.
  b. Description of the important conditions under which the behaviour will be expected to occur.
  c. Description of how well the learner must perform to have his behaviour considered acceptable.

3.3 Problem Analysis - In this stage we try to locate areas of the course which are likely to cause problems for teachers or students. Sources of information on likely problems include research literature on teaching and learning, previous performance in the course or in similar courses, and experience of other institutions.

3.4 Strategic Decision - They include a description of the teaching methods to be used and the learning material to be developed.

IV. PROGRAMMED INSTRUCTIONAL MATERIALS

Programmed instruction is coming to be regarded as a means of allowing users to achieve important instructional objectives without the necessity for the instructor's personal intervention as a "dispenser of knowledge."

The following aspects of the topic will be examined:

- Characteristics of the process itself.
- Process of program development.
- Some types of programming strategies.

1. Programmed Instruction - A Process

A process can be defined as a controlled sequence of events leading to a desired outcome. Programmed instruction is a process. It is a sequence of events leading to a set of desired instructional outcomes, each time the sequence occurring as designed. In fact Markle [Ref. 1], defines instructional programs without reference to format: "We define an instructional program as a reproducible sequence of instructional events designed to produce a measurable and consistant effect on the behaviour of each acceptable student .... Such a definition specifies neither the medium of presentation nor the theoretical psychological principles governing program construction."

Perhaps here programmed instruction should be compared with ordinary instruction.

According to Corey [Ref. 1], since programmed instruction refers to a well-disciplined and experimental approach to the development of instances of systems of instruction, there are several characteristics of this discipline and experimentation that depart from most instances of instructional planning. Some differentiating characteristics are the care and explicitness with which the behaviors intended to be the outcomes of instruction are described, the psychological sophistication of the analysis of these behaviors, and the experimental approach to sequencing the elements resulting from this analysis for instructional purposes, with vigorous attention to empirical evidence for improving the instruction. Another characteristic of programmed instruction is the careful development and control of the instruction stimuli or the instructional environments. Moreover programmed instruction is planned to procure a continuous and explicit response or activity on the part of the learner under circumstances that allow him to know at once whether or not his responses are appropriate.

Two additional characteristics of most instances of programmed instruction have to do with the difficulty of the behaviors (standard or level of performances) being taught and the relative self-sufficiency of the instructional program in bringing these behaviors about.

Of course, many of the more familiar types of instructional materials also have some of these characteristics. Textbooks, for example, are usually carefully planned and developed, they lead the user from simple or known concepts to those more complex or sophisticated, and they facilitate some self-instruction. However, the program is designed to develop student behavior; the book is characteristically designed to present a given subject in more or less depth. The program is tested and modified until the desired behavior is achieved on the part of the student; The book is modified until either, colleagues, and publisher are pleased with the content.

Some advantages claimed for programmed materials are that they permit individualization of instruction, can reduce the amount of time required to teach, can improve the level of performance and reduce the incidence of failure among students, and permit assessment of reasons for successful and unsuccessful experiences.

2. The Process of Program Development

As a minimum, seven basic steps may be seen as required in developing effective programmed instructional materials. They can be diagramed in the following way.

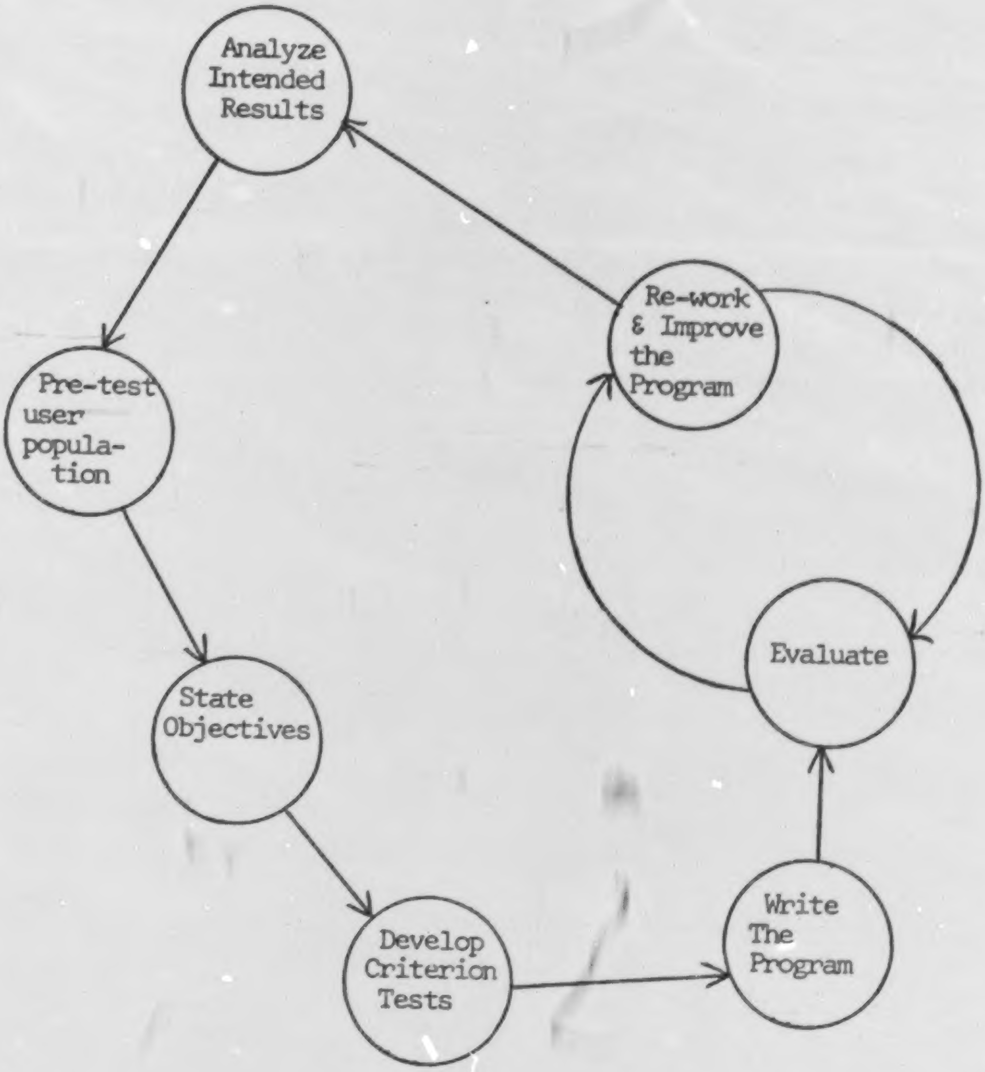

Analyze Intended Results
Pre-test user population
State Objectives
Develop Criterion Tests
Write The Program
Evaluate
Re-work & Improve the Program

Fig. 6

Thus the steps, in their usual order of occurrence, are:

2.1 Analyze and specify intended results - Define the scope of knowledge to be acquired by the student and the details of the task he must perform after instruction.

2.2 Analyze and pretest the student population to be taught - Find out who they are and what they know and can do before exposure to the instructional program. This data should include their physical characteristics and abilities, previous education motivation, interests, attitudes, biases and prejudices, and specific prior knowledge regarded as relevent to the instruction ahead.

2.3 Develop and write down appropriate instructional objectives - These should be clear statements of instructional intent characterized as follows:

- good objectives say something about students.
- good objectives describe the behavior or performance of users.
- good objectives deal with ends rather than means. They describe a product rather than a process.
- good objectives describe the condition under which users will perform the terminal behavior. (open book or not, for example)
- good objectives include information about the level of performance to be considered "acceptable."

2.4 Specify the criterion tests - Criterion tests are constructed solely from the objectives. Their purpose is to determine how well students perform at the end of instruction with respect to each important objective.

2.5 Write the program - Develop details of the program in writing as a plan based upon all the foregoing and following procedures. A major task connected with this step is that of selecting or developing appropriate learning resources (such as programmed books, ordinary books and other printed materials, various non-book media, firsthand experiences) and organizing their use to achieve objectives of the program.

2.6 Evaluate the success of the program - Compare the final performance of each student with criterion measures suggested for each important objective, under the circumstances and within the levels of acceptability prescribed.

2.7 Rework and improve the program - This is a continuing cycle of activity which will involve further work with all aspects of the program - delineation of objectives, clarification of criterion tests, revision of program content, development or selection of improved learning resources, and better means of evaluation.

The following flow chart, constructed by the National Society for the Study of Education [Ref. 1], shows the numerous points of decision and testing involved in the empirical development of complex instructional programs. It also emphasizes the definiteness of intended outcomes as well as the structured nature of the process itself (one step leading to the next, recycling as necessary to improve the product until it reaches its goals).

A GENERALIZED FLOW CHART OF PROGRAM DEVELOPMENT

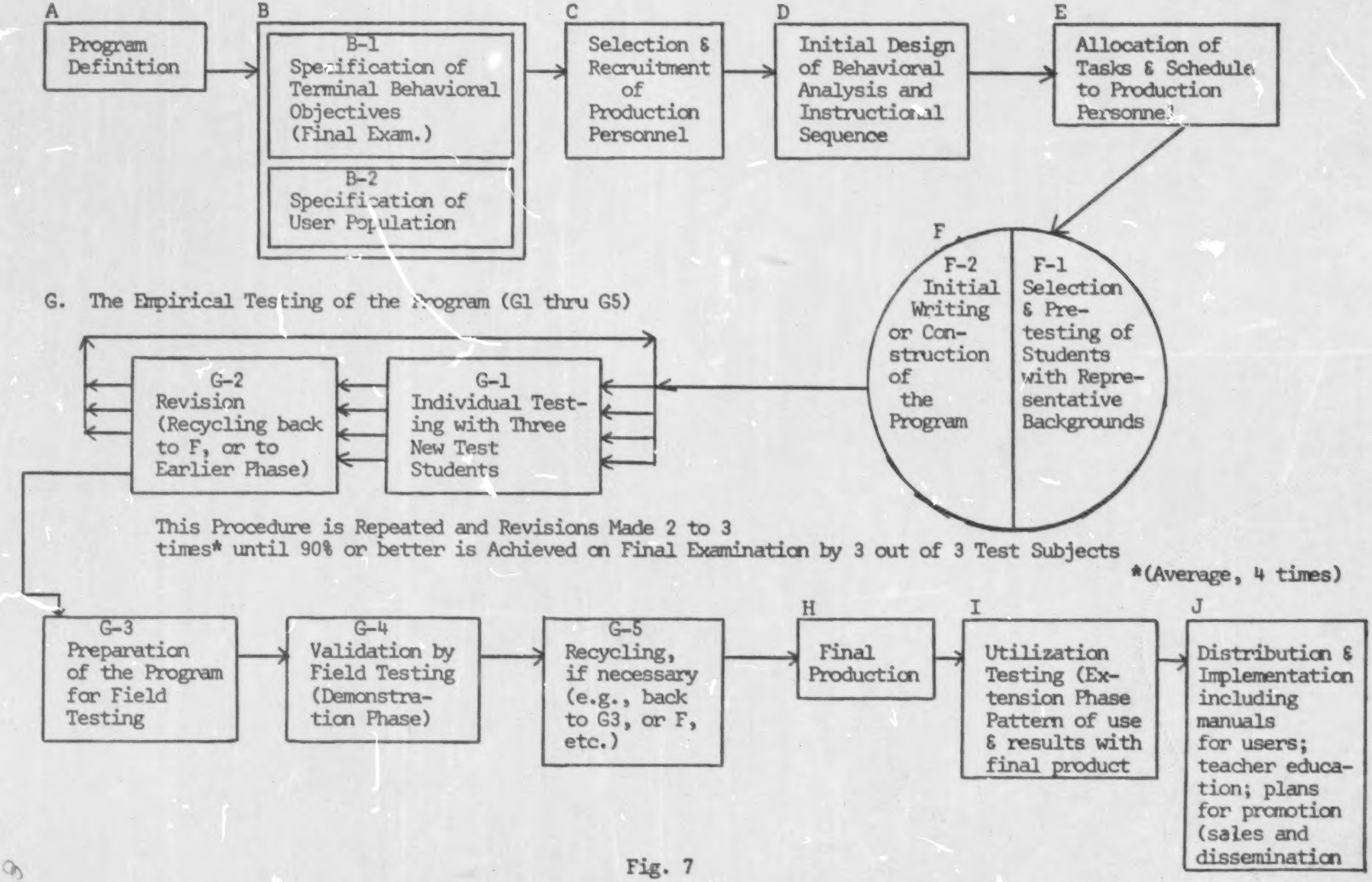

A
Program Definition
B
B-1
Specification of Terminal Behavioral Objectives (Final Exam.)
B-2
Specification of User Population
C
Selection & Recruitment of Production Personnel
D
Initial Design of Behavioral Analysis and Instructional Sequence
E
Allocation of Tasks & Schedule to Production Personnel
F
F-2
Initial Writing or Construction of the Program
F-1
Selection & Pre-testing of Students with Representative Backgrounds
G. The Empirical Testing of the Program (G1 thru G5)
G-2
Revision (Recycling back to F, or to Earlier Phase)
G-1
Individual Testing with Three New Test Students
This Procedure is Repeated and Revisions Made 2 to 3 times* until 90% or better is Achieved on Final Examination by 3 out of 3 Test Subjects
*(Average, 4 times)
G-3
Preparation of the Program for Field Testing
G-4
Validation by Field Testing (Demonstration Phase)
G-5
Recycling, if necessary (e.g., back to G3, or F, etc.)
H
Final Production
I
Utilization Testing (Extension Phase Pattern of use & results with final product
J
Distribution & Implementation including manuals for users; teacher education; plans for promotion (sales and dissemination

Fig. 7

3. Types of Programming

The known types of programming can best be classified in two broad groupings:

3.1 Linear Programming - A linear program is one in which the sequence of information presented to the student is fixed; that is, all students are given the same stimuli in exactly the same sequence. Two kinds of response have generally been asked for in the linear program.

- -A written or button-pressing indication that a correct answer has been recognized (e.g. multiple-choice item)
- -A written indication that an item has been learned or understood.

(These linear program patterns have a historical base in the early work of Sidney L. Pressey and the more recent work of B. F. Skinner). With both kinds of linear programming, all students are required to complete the same items in the same order of progression through the program. Learning tasks are presented in small steps and with a large number of learning cues. However, the ultimate objective is to use as few cues as possible and to force the student to derive his answers from understanding the frames. Reinforcement of correct answers is the primary concern. The program must be completely self-contained and adequate to carry the student from start to finish without aid from other sources. In linear programming, adaptation to individual differences is not carried out by the program itself, but rather by allowing each learner to take whatever amount of time he requires to complete it.

3.2 Adaptive Programming - Here the presentation sequence is ajusted on the basis of what the student does. A program may be designed to be more or less adaptive; it may select the next presentation item on the basis of student's response to the previous one or on the basis of his responses to the last several items.

Adaptive programming provides for individual differences. One form of this type of programming is called "branching" (developed first by Crowder [Ref. 4]. With the branching pattern students are required to recognize and to choose correct answers if they are to proceed without "relearning detours" (corrective assignments) or if they are to skip program portions for which they already possess sufficient skill or knowledge. Branching programs are provided in books, "scrambled books" or on machines (which use filmstrips and present information and tasks on individual frames). Either way, the student responds to a question and is directed to another page or frame where this response is evaluated. There, if his response is incorrect, he is given further information, usually including some explanation of why he was wrong. He may be told to return to the original page and try again, or he may be asked to go to a new page for more information before trying a somewhat different version of the same question.

Branching questions are not always dichotomized as "right" or "wrong." Some questions or problems call for opinions or trouble shooting decisions and so have more than one appropriate answer. In the event that responses reveal some fundamental lack of knowledge considered necessary to proceed with the program, students may be subsequently "branched" into side studies to prepare them to take the next steps in the "main line" of the program.

3.2 The Evolution of Programming Strategies - The following graphical outline suggests the idea of adaptability of a program and the reason for different program presentation methods.

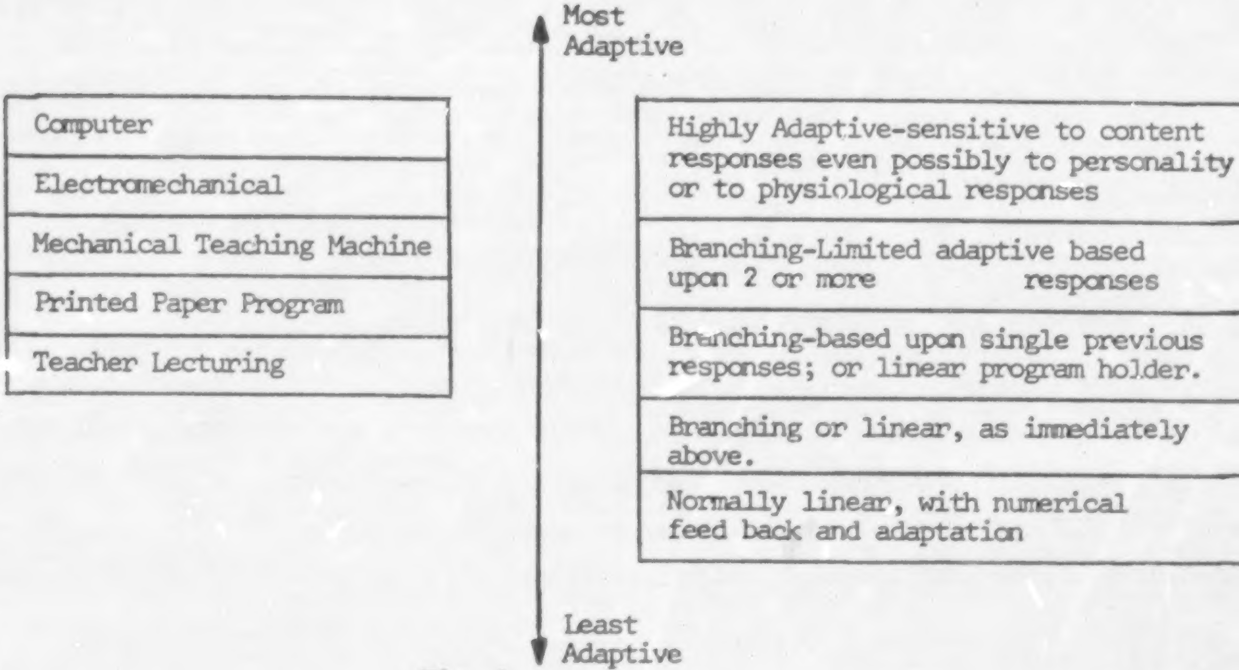

Most
Adaptive
Computer
Electromechanical
Mechanical Teaching Machine
Printed Paper Program
Teacher Lecturing
Highly Adaptive-sensitive to content responses even possibly to personality or to physiological responses
Branching-Limited adaptive based upon 2 or more responses
Branching-based upon single previous responses; or linear program holder.
Branching or linear, as immediately above.
Normally linear, with numerical feed back and adaptation
Least
Adaptive

Fig. 8

3.4 Teaching with Programmed Materials - It is reasonable to expect that all teachers ought to be prepared to learn how to use programmed materials selectively, to learn to capitalize on the special advantages of programmed instruction, and to be guided by the knowledge that the primary aim of programmed instruction is to improve learning.

V. COMPUTER - ASSISTED INSTRUCTION - CAI

1. Types - Computer-assisted instruction has multiple definitions which are related to a variety of applications of such systems. Perhaps the best functional definition was derived by Suppes [Ref.11],who identified three kinds of activities as comprising CAI. These were namely:

- Drill and practive activities.
- Tutorial activities.
- Interactive or problem - solving activities.

Almost all indications affirm that the primary area of interest has been in the tutorial mode of instruction. This mode clearly represents the type of teaching which is currently available in programmed instruction.

For example, a content area is systematically analyzed and performance objectives are developed. The student receives all of his instruction in a particular topic via an interactive dialogue at the computer terminal.

The second type of CAI, the drill and practice type of activity, is best represented by Suppes' activities at Stanford. The drill and practice materials contain information which the student has previously encountered in the classroom, but needs continual practice, immediate feedback, and repeated presentations of difficult material in order to achieve these basic skills.

The third area within the Suppes definition of CAI activities is that of problem solving. CAI problem solving involves the activities of simulation or gaming. Gaming and simulation are often used when a student already has the basic information about a topic. The student is required to utilize this information in his interaction with the computer in order to derive a deeper understanding of the concepts which he has learned. For example, medical diagnosis simulation is a prototype of this type of CAI. Games and simulations are generally very difficult to program, and this area has probably been least investigated in terms of its learning potentialities for the student.

2. CAI in the Learning Process

Almost all opinions agree that the use of computers for record-keeping of instructional materials or even as aids to assist the teacher in doing time consuming tasks (grading homework, exams, preparing grades, etc.) is not worthwhile for a very simple reason: cost is prohibitive in an operational setting at the present time. Furthermore the problem is not to help the teacher but to enhance the chances of promoting the learning process as a whole. To what extent one can combine effectively computer use with existing teaching experiences (computer-based multi-media courses) for the purpose of improving the learning process is still in the research and/or development stages.

However, an experiment in this area was carried out in Florida State University [Ref. 6],to determine the useful aspects of the process.

A physics course was chosen and the following actions were undertaken to transform it into a computer-based multi-media course.

The lecture presentations of the professor who was responsible for the classroom version of the course were video-taped. This tape was utilized to do an analysis of the content of the course and to determine the information which was being presented to the students. Copies of the course tests were secured, the types of skills which were required in order to solve the questions in these tests were analyzed, and the homework problems which the students were required to do were also analyzed.

A series of CAI homework review problems was set up and made available on an optional basis to the students in the regular physics course. The students were offered an opportunity to get homework and test-like questions which were similar to those they would be receiving on the test. The computer supplied answers to the questions as well as remedial feedback and reinforcement.

A great deal of data was gathered and the video tapes were used to go about the development of the individual lesson sequences. It was decided to make the CAI physics course a multi-media course, i.e., not to depend solely upon the computer as the presentation device, but to take advantage of film loops produced in experiments usually carried out by the instructor in the classroom, the audio tapes which were compressed versions of some of the lecture presentations, and the textbook which the students were required to read prior to starting a lesson.

The CAI system itself was used for monitoring and guiding the students throughout the lessons, for continually reviewing their progress in both the testing and review mode, and for providing remedial information to them. The efforts of several professors from the physics department, were combined with that of several "coders" (experts in the CAI language utilized by their computer) and programmers to develop and complete the whole system. Finally, proctors were used to work with students and to help them.

The outcome of this first study was a significant superiority in the final grades of the students who took the course by CAI as compared to a matched sample of students from the conventional course. There was also a considerable time savings.

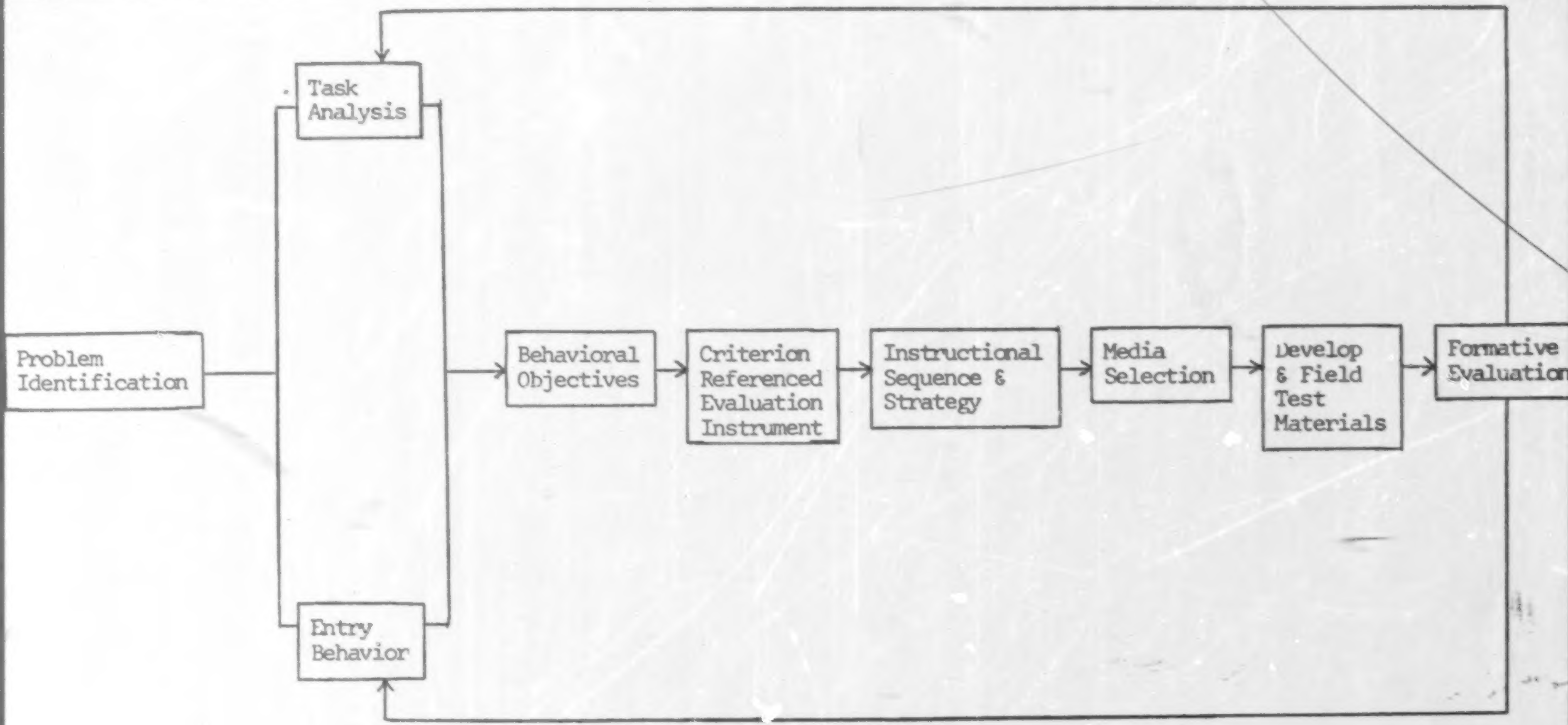
3. Conclusions About CAI

A careful analysis of the preceding activities and of the results obtained reveal the following propositions about CAI course (curriculum) development:

3.1 The systems approach to the development of instructional materials is introduced as a model (Dick's) [Ref. 3],and summarized in a flow chart. The steps in the model are: problem identification, analysis of the task, knowledge of the student population, formulation, of behavioral objectives on the basis of the behaviors expected of the students on the tests, specification of the instructional strategy, media selection, field testing, and finally the formative evaluation. Here the similarities between this model and the steps specified in the section titled "Course Development" should be noted.

3.2 The instructional model employed above was derived from the results of numerous research studies [Ref. 5],conducted at the CAI Center at Florida State University and elsewhere, which seem to indicate that while tutorial CAI is an effective instructional strategy, it is unlikely that it is going to make a significant impact on education because of the cost associated with one student ulitizing a terminal for relatively long periods of time during each instructional session. Therefore, other types of computer strategies (simulation, on-line problem solving, CMI) should be investigated to determine the role they can play in education.

3.3 The higher the terminal criterion performance expected of the students for whom the materials are prepared, the more difficult will be the programming of the course and the more complex will be the instructional strategy. These complexities will complicate the development of instructional materials.


Problem Identification
Task Analysis
Entry Behavior
Behavioral Objectives
Criterion Referenced Evaluation Instrument
Instructional Sequence & Strategy
Media Selection
Develop & Field Test Materials
Formative Evaluation

Model for the systems approach to the development of instructional materials
(After Dick [Ref. 3]).

Fig. 9

In conclusion, CAI is a tool which should fit within a curriculum and within instructional setting. That is, it should not carry the entire instructional load but should be part of a multi-media resource. One concept to keep in mind, however, is that the greater the variety of media which one chooses to employ, the more complex will become the logistics for the student and the more difficult the total implementation process.

Finally, the very nature of the CAI system makes it a very private learning situation in which the student can make numerous mistakes and the computer will continue to provide him with the type of material which he needs in order to master certain basic skills. The same situation repeated in a classroom could be embarrassing and humiliating. Moreover, the computer has infinite patience and can even be supported in its interacting with the student.

VI. AUDIOVISUAL TECHNIQUES

In this section the use of audio visual techniques, their research evaluation, and various theoretical interpretations of their significance will be surveyed. The techniques of educational broadcasting, particularly the use of educational television will also be considered. The main problems and challenges of audiovisual education today revolve around the use of television, which not only constitutes a new and important technique in its own right, but also serves as a means of utilizing and integrating all other forms of audiovisual instruction.

1. Educational Significance of Television

All indications are that radio broadcasting orginated in educational purposes, but while educational radio has extended university influence in several special areas, it has not influenced classroom teaching techniques to any great extent. On the other hand the educational significance of television was recognized from its inception, but the costs involved delayed its application to educational purposes. However, with new recording techniques, it is no longer the cost factor that is delaying the use of educational television but the importance given the computer in all research in science education.

Educational television makes use of two types of transmission: broadcast or open-circuit, and closed-circuit. The latter uses closed-circuit camera-monitor chains linked by wire and is less expensive. Color television and stereoscopic television have limited use in education. Color sometimes is used for medical and biological demonstrations, and stereoscopic displays are valuable in training remote control techniques. Television recording capabilities make possible the storage of unusual demonstrations for instructional use, and immediate playback of a televised record is valuable in training in complicated or dangerous skills.

Educational television is a natural medium for many specialized demonstrations of laboratory, therapeutic, and medical procedures. However, much educational television teaching is conventional in nature, following established procedures of lecturing with coordinated visual displays.

The point has been made earlier that one of the most significant characteristics of television as an educational medium is that it can incorporate all other forms of audiovisual display, i.e., any type of visual or auditory material can be transmitted by means of television. There is a teaching system called "telemation" which does indeed incorporate all audiovisual techniques but in a somewhat more elaborate fashion than that provided by television alone. The main purpose of telemation is to provide four or five sources of audiovisual stimulation to the student automatically and, if desired, simultaneously. Telemation has been referred to as an automated classroom. The audiovisual equipment is: two slide projectors, a movie projector, a tape recorder, teleprompter units, an opaque projector, a four-speaker sound system, controlled lighting, a television projector, and an elaborate system of electronics to control all these. The cost of modifying a classroom and installing the equipment is quite high. Moreover no educational advantage has been achieved with the telemated classroom that could not have been gained with simpler equipment at a fraction of the cost.

Finally the common motivational interpretation is that audiovisual devices function as aids to learning by arousing interest and orienting the student in the right direction.

2. Evaluation of Audiovisual Learning

The main results may be summarized as follow-:

2.1 Studies of the motivational effects of films and graphics have had inconclusive results. There is no conclusive evidence that interest in instructional materials correlates highly with their teaching effectiveness.

2.2 Audiovisual techniques in common with other instructional methods have very specific learning effects. Films may be equal or superior to conventional methods for some areas of learning, including training in perceptual-motor skills. Tape recorded lectures may be as effective as live teaching for limited purposes.

2.3 The audio channel is more effective than print only for poor readers or when the material is easily understood. Evidence indicates an advantage for combined channels over a single channel, although the addition of pictorial material to verbal sometimes retards learning of the specific items used.

2.4 Evaluation of audio-visual instruction are hampered by the fact that there are no adequate tests of nonverbal learning. Verbal tests favor verbal instruction and thus do not permit valid comparison between verbal and nonverbal media.

2.5 There are no general rules for sequencing demonstration, practice, and review units. The optional sequence appears to depend on the complexity and intrinsic organization of the particular task.

2.6 In general, active participation during film showings aids learning, but covert participation may be just as beneficial as overt. Audiovisual materials should be designed to elicit the desired responses, either overtly or covertly.

2.7 Special embellishments of films and graphics do not increase learning unless they aid specifically in making important discriminations or in promoting understanding. Devices that call attention to important points aid learning of those specific points.

2.8 There are no significant differences between the effectiveness of television teaching and that of conventional teaching.

2.9 Although "educational television" is judged to be an effective way of demonstrating laboratory and other procedures, some evaulative studies have turned up no significant differences between the achievements of television and that of verbal laboratory instruction.

2.10 The final worth of educational TV must be judged on the basis of what it can do better than other techniques. Its special features are remote transmission of audiovisual displays, immediacy, presenting demonstrations, expert teaching and timely events, and recording and retrieval possibilities.

VII. THE SELF-INSTRUCTION SYSTEM, "ALF"

1. Components of A Self-Instruction System

Slamecka of Georgia Tech describes a self-instruction system as a tutorial system characterized by the absence of the live instructor as the dispenser of knowledge.

The components of a self-instruction system are a structured memory and a programmed preceptor. The memory stores learning materials in a form suitable for transmission and for perception by remotely located learners. It contains learning units of variable length, stored in a form suitable for perception by the learner through his aural and visual senses. The minimum necessary storage includes the primary information contained in a black board lecture, i.e., synchronized narrative speech and kinectic graphics. Each "audio-graphic" learning unit is identified with respect to its objective (learning goal), and is linked to its preceding prerequisite unit or units. Thus for any given learning goal the optimal, the shortest, and the alternate "lists" of learning units can be specified. Additional description of learning units by subject permits the identification, via an index, of subject-related presentations.

A programmed preceptor controls the transmission. It is programmed to transmit learning materials from mmory to remote locations such as classroom and other types of conveniently located learning sites.

The control over the system is partially vested in the programmed preceptor, and in part it resides with the learner. User-imposed control over the system is of 2 types. On-line control gives the learner the ability to start, stop and repeat a presentation and to jump at any time to any other learning unit in the system. Using these commands, learner can orient the selection of learning units offered by preceptor, and in such a manner participate, on line, in the design of his learning strategy. There is a second control mechanism which interposes between learner and preceptor the services of a human tutor; it is tantamount to an appointment or a conference with a teacher prior to overriding the programmed preceptor. Incurred in this type of control will usually be a time delay.

The self-instruction system operates in two modes, scheduled and on-demand. Scheduled operation is authorized by preceptor programmed to release a predetermined schedule of presentation, each running for a specified period of time to specific learning sites, and at specific times. In the on-demand mode, preceptor receives and responds to requests for transmission of random learning units or unit sequences issued from open classrooms. Both modes of self-instruction can serve, optionally, either group audiences (e.g., a class) or individual learner.

The self-instruction system can be shown schematically as follows:

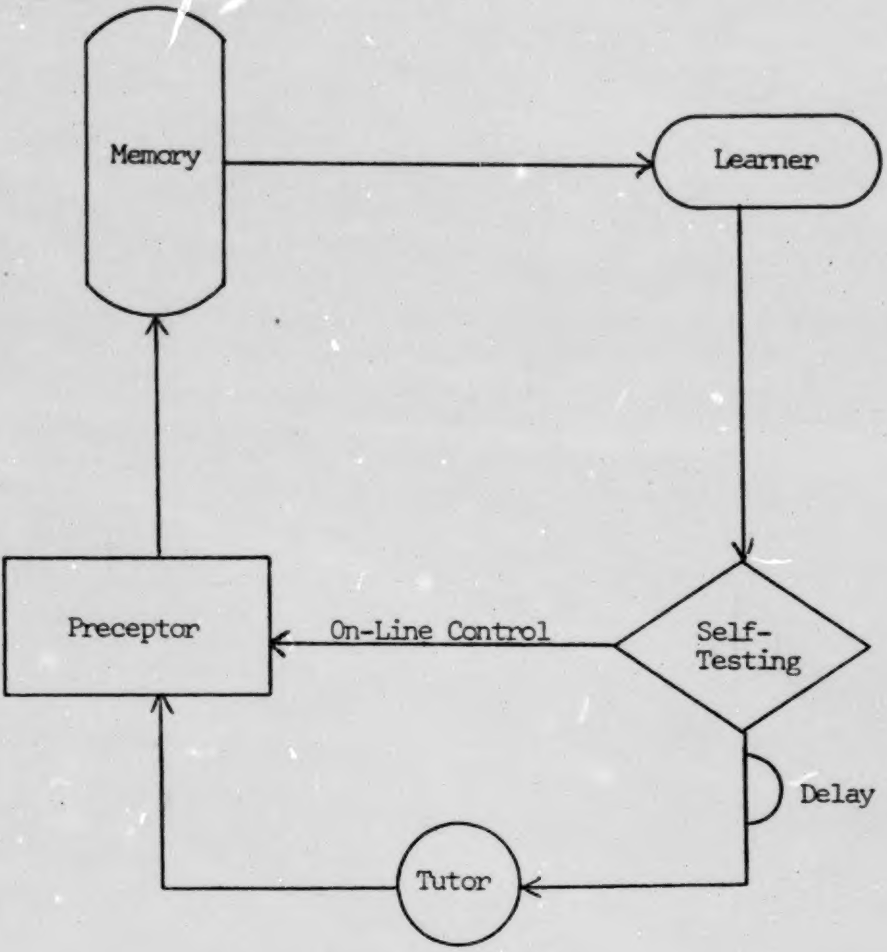

Memory
Learner
Self-Testing
On-Line Control
Preceptor
Delay
Tutor

Fig. 10

2. Audiographic Learning Facility (ALF)

2.1 Objectives- The Audiographic Leaning Facility is an example of a self-instruction system. The main objectives of the system are:

- to define the minimum content of memory necessary for adequate self-instruction.
- to develop a model of the self-instruction process, and to describe its pedagogic requirements.
- to define a unit of learning materials suitable for self-instruction, and to specify its content elements.

- to define the data elements required by preceptor for the purpose of designing and effecting valuable learning strategies under program or learner control.
- to store in memory a small subset of knowledge for experimental self-instruction.
- to design a physical facility permitting the demonstration of self-instruction by group and individual learners.
- to obtain gross initial indicators of the self-instruction system behavior, economics, and effect on human learner and teachers.

2.2 Characteristics of ALF - The main characteristics of ALF are its storage of narrative speech and line graphic "blackboard" lessons as the modular contents of memory, and its capability of actively involving learners in the design of their learning strategies. The communication between preceptor and learner and the transmission of audiographic learning materials employ standard telephone lines.

2.3 Conclusions - The analysis of the ALF reveals the following conclusions:

- the learning materials stored in audiographic form constitute a significant improvement over average live classroom instruction with respect to the following qualitative factors: organization of the subject materials, clarity of presentation, and economy of time.
- devices and descriptors can be devised which cumulatively comprise a dynamic, relational index to the logical and pedagogic structure and to the use of large bodies of substantive knowledge stored in the system.
- devices can be devised and included in the memory of the system to facilitate learning diagnoses and self-testing by learner.

- the joint use of these devices and the preceptor's record of the structure of the stored knowledge enables the learner to formulate and revise on-line, efficient, and effective learning strategies, and thus to compensate for the absence of a human teacher in self-instruction.
- the development of the memory contents is highly economical in comparison with other media of instruction, both live (classroom teaching) and recorded (television, programmed and computer-assisted learning); the preparation of a 60 minute audiographic lecture, including the organization and recording of materials, requires approximately five man-hours of effort.
- initial reactions to the ALF by students and faculty are not discouraging.

VIII. CONCLUSION

This report is concluded with a tentative matrix, which shows in its entries the possibility of using the outputs of the existing information centers in the design of inputs to the teaching devices already considered.

Clearly, a more detailed study of this matrix is required (classification by subject matter, level of difficulity, etc.) to obtain an analysis of the potential information requirements for new educational tools and systems.

	Initiative Outputs			Responsive Outputs				Microform Services (Microfiche etc.)	Magnetic Tape Services
	Announcement Lists ' Bookform Catalog	Research in Program Index	Biographical Index Directory	Bibliography	Spec. Document Search	Hard Copy Retrieval	State of the Art Report		
Programmed Instructional Materials	x				x	x	x		x
Computer-Assisted Instructions					x	x	x	x	x
Audio-visuals						x	x	x	x
Self-Instructional Systems	x					x	x		

Fig. 11

IX. REFERENCES

1. Corey, Stephen M., "The Nature of Instruction." In Programmed Instruction Sixty - sixth yearbook, Part II. National Society for the Study of Education. Chicago, University of Chicago Press, 1967. p. 22-23.

2. Crowder, Norman A. "Automatic Tutoring by Intrinsic Programming. "In Lumsdaine, A.A., and Robert Glaser, eds.., Teaching Machines and Programmed Learning. Washington, D.C. National Education Association, 1960. p. 286-298.

3. Dick, W. and P. Gallagher, Systems Concepts and Computer-Managed Instruction: An Implementation and Validation Study. Tech Memo.

4. Eraut, Michael R. "An Instructional Systems Approach to Course Development." AV Communication Review, 15;92 (Spring, 1967).

5. Eraut, Michael R. The Design of Variable Input Learning Systems. "In Dunn, W. R. and A. Holroyd, eds , Aspects of Educational Technology Vol. II. London, Methuen, 1969.

6. Hansen, D. N. "Development Processes in CPI Problems, Techniques, and Implications." Project NR 154-280. Tech Memo No. 11, October 15, 1969. CAI Center, Florida State University.

7. Mager, R. F. "On the Sequencing of Instructional Content." Psychological Reports, 9:405 (1961).

8. Markle, Susan M., "Empirical Testing of Programs." Programmed Instruction, Sixty-sixth Yearbook, Part II. National Society for the Study of Education, University of Chicago, Press, Chicago, 1967. p.104.

9. National Society for the Study of Education. Programmed Instruction. Sixty-sixth yearbook Part II. Chicago University of Chicago Press, 1967. p.58.

10. Scriven, M. "The Methodology of Evaluation." In Stale, R., ED., Perspectives of Curriculum Evaluation. Chicago. 1967.

PART FOUR

DESIGN AND OPERATION OF THE STITE SYSTEM

PART FOUR

DESIGN AND OPERATION OF THE STITE SYSTEM

I. EXAMPLES OF FEATURES OF STITE AND THEIR POSSIBLE USES

1. Searching Functions

1.1 Simple information retrieval, facts, specific knowledge, tables, materials, chemicals, temperatures, etc., as requested from outside or as supporting processed request.

1.2 Literature or research report retrieval relevant to certain topic, list of existing courses at universities or other schools, lists of lectures, actual or planned for future.

1.3 Special lists of new information available.

1.4 Lists of knowledgeable professionals available for direct requests, discussions, or advice and arrangement for their communication, including voice, picture, and drawings.

1.5 Existing methods or programs available commercially, or available through agreement with public or private owners.

2. Switching Functions

2.1 On-line demonstration at site, SI, based on materials owned by site, S2.

2.2 On-line live demonstrations of unique biological, medical, physical, chemical laboratory experiments or rare experiments and procedures.

2.3 Live lectures of distant lecturers, classes and group discussions by remote participants, facilitation of participation in problem solving processing for remote participants.

3. Internal Features

3.1 Course design - automated grouping of subjects into sub-topics based on the material, knowledge of the class, intentions, etc., and course updating with new information.

3.2 Demonstrations prepared from retrieved materials, films, special formatted data, graphs, and closed circuit TV tapes.

3.3 Semi-automated or fully automated preparation of quizzes or tests, their evaluation, recordings, statistics, and grading.

II. THE TEACHER'S ROLE IN USE OF STITE SYSTEM

With the increasing power of the STITE system to provide information to the teacher and making much of that information directly available to the student as well, the role of the teacher in the educational process will gradually change. The uniqueness of the educator's knowledge will be augmented by his access to STITE. On the other hand, however, automated search and retrieval transmitted directly to a student will eliminate the necessity of the possession of that knowledge on the part of the teacher. In more advanced uses of STITE the teacher need not even be fully aware of the exact information being transmitted.

A two way shift of the role of the educational process can be envisioned as a result of both increasing power and use of STITE. In relation to the student, the teachers' interface will be gradually described more and more in terms of advisor, planner of education, manager of educational process, or strategist of education, rather then being the direct transmitter of the specific knowledge and experience as it is today.

In relationship to the educational process, the teachers' experience in research and in educational methodology will be utilized more toward improvement of the STITE system and less toward direct work with students, though the latter probably will not be completely eliminated. Improvements in the methods of presentation of the transferred material and in the degree of sophistication of material will require that the personnel in charge of those improvements be at least on the level of today's educators in terms of their knowledge, educational experience, and research qualities.

III. OPERATIONAL SCHEME OF STITE

1. Definitions

1.1 STITE system - Scientific and technical information transfer for education.

1.2 Request (RT) - A task directed to STITE by an Educator.

1.3 Request schedule (RTS) - A schedule which is a result of the first operation of STITE on the request (RT) and which lists necessary activities and their sequence.

1.4 Process for development of the schedule (PRTS) a schedule under which RT will be processed, listing future activities, their sequence, and conditions for their implementation.

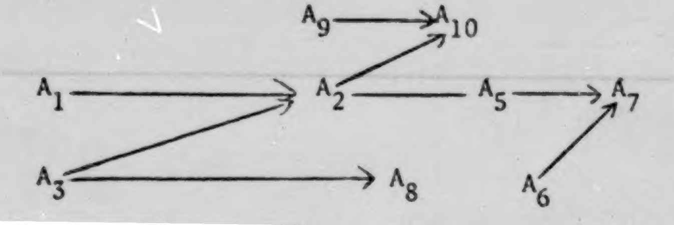
The process, PRTS, can be performed initially as human activity which will later be made a man-machine interaction and finally fully automated. PRTS has to decide the activities necessary for complete processing of the request such as:

-input formation.
-request for certain information.
-request for help or human intervention.
-order in which the activities are to be performed.
-conditions if more than one activity precedes.
-que information as to the importance and urgency of each activity.

2. Description of Scheduling Technique

The scheduling technique will be similar to PERT-system scheduling, or the PETRI - a system in which a collection of activities is prepared and a network is created showing which activity and under what conditions the system can be activated. The schedule is made in the form of a directed graph where nodes are the activities and arrows show their ordering. Any activity can be started if, and only if, all activities of preceedings nodes have been successfully finished.

For example, let A_1, A_2, and A_3 be activities ordered by the graph.



Let A_1, A_2, A_3 represent accomplished activities. Then activities that can be started at any future time are A_5, A_6, A_8, while A_{10} still has to wait for A_9.

Let:

A = set of all activities

A_k = activity k

A_b^k, b = 1,2...b = set of all immediately preceeding activities A_k.

0 = value of unfinished (started or not started) activity

1 = value of finished activity

Then the condition for starting activity A_k is:

$$\Pi A_b = A_1^k . A_2^k ... A_b^k = 1 \quad \text{(M1)}$$

for networks with one alternative schedule or

$$\Sigma\Pi A_b = 1 \text{ or } B(A_b) = 1 \quad \text{(M2)}$$

For networks that contain more than one alternative schedule, where Σ, Π, B stand for Boolean sum, Boolean product and Boolean expression, respectively.

Assuming that there are also external conditions C_k for the initiation of A_k (e.g., the centre that is to be interrogated by A_k will be closed next month, etc.) and that each condition C_m^k C_k, m = 1,2...m described as Boolean variable where:

C_m^k = 0 = condition is not satisfied

C_m^k = 1 = condition is satisfied

$C_k = B(C_m^k)$ is a Boolean expression describing outside conditions for initiation of A_k

then (M1) is replaced by

$$\Pi A_b . C_k = A_1 A_2 ... A_b . B(C_m^k) = 1 \quad \text{(M3)}$$

for one alternative schedule and (M2) is replaced by

$$\Sigma\pi A_b . B(C_m^k) = 1 \quad \text{(M4)}$$

for multialternative schedule.

Regarding the activities as Boolean variables offers adequately powerful representation of the graph (with all alternatives) enabling representation of the graph in the form of Boolean conditions and use of the graph for control of the corresponding start of activities in proper order.

In case of an alternative schedule, strategy must be determined which will decide when and how available alternatives will be chosen. Examples of the strategies:

- try less expensive alternatives first
- try the fastest alternative first
- follow all alternatives at the same time and stop when first one is implemented.

Two alternatives will be followed in our research:

- representation of the whole schedule in form of Boolean condition suggested above.
- representation of the schedule in graph-table with conditional transitions.

After both approaches have been studied in detail and carefully evaluated the selection of the appropriate approach or combination of approaches for the STITE system will be made.

3. Change in General Condition of STITE

3.1 Type of change - a number of types of general condition change [GCCH] can be recognized.

3.1.1 Internal change - caused by time, derived from real time clock, moving ahead hours, days, dates or any real time unit involved in the planning

3.1.2 External change - new information arrived at a terminal or message buffer and needs to be inserted into A for processing.

3.1.3 Interaction requested from outside - STITE system is to switch to interacting node in order to interrupt processing, place the request into Q with highest priority, or to parallel process for interactive activity with no interruption of Q.

3.1.4 Interaction requested from inside to interface with outside source or to deliver the generated data.

3.1.5 State of Q - determines whether system is to be active or inactive.

Activity Q is formed from all activities, called internal activities, that are to be performed by STITE. Regarding Q as a set of activities I to be performed, there is: $''\{\{I\}\} = Q$

Internal activities are:

- -request for processing: make the schedule
- -condition C has been formed: identify all requests affected by C, insert then into Q marked by C
- -condition C of the request has changed: mark ready activities for initiative, insert then back into Q
- -activity is to be initiated: check the conditions for initiation (whether changed while waiting in Q), initiate the activity Q is empty: system inactive

Distribution of the control among the levels is shown schematically in Fig. 4. It is a three level hierarchy governed by both internal and external conditions of STITE. Conditions C_1 through C_5 form state of the element L_1 that transformes them into controlling signals for level L_2, etc.

It will have to be decided later whether or not interrupts generated in L_1 and directed toward L2 or L3 levels will be necessary or useful.

The concept of hierarchy will likely be modified according to the centralized versus decentralized concept of STITE, or in consideration of other conditions uncovered by more detailed design.

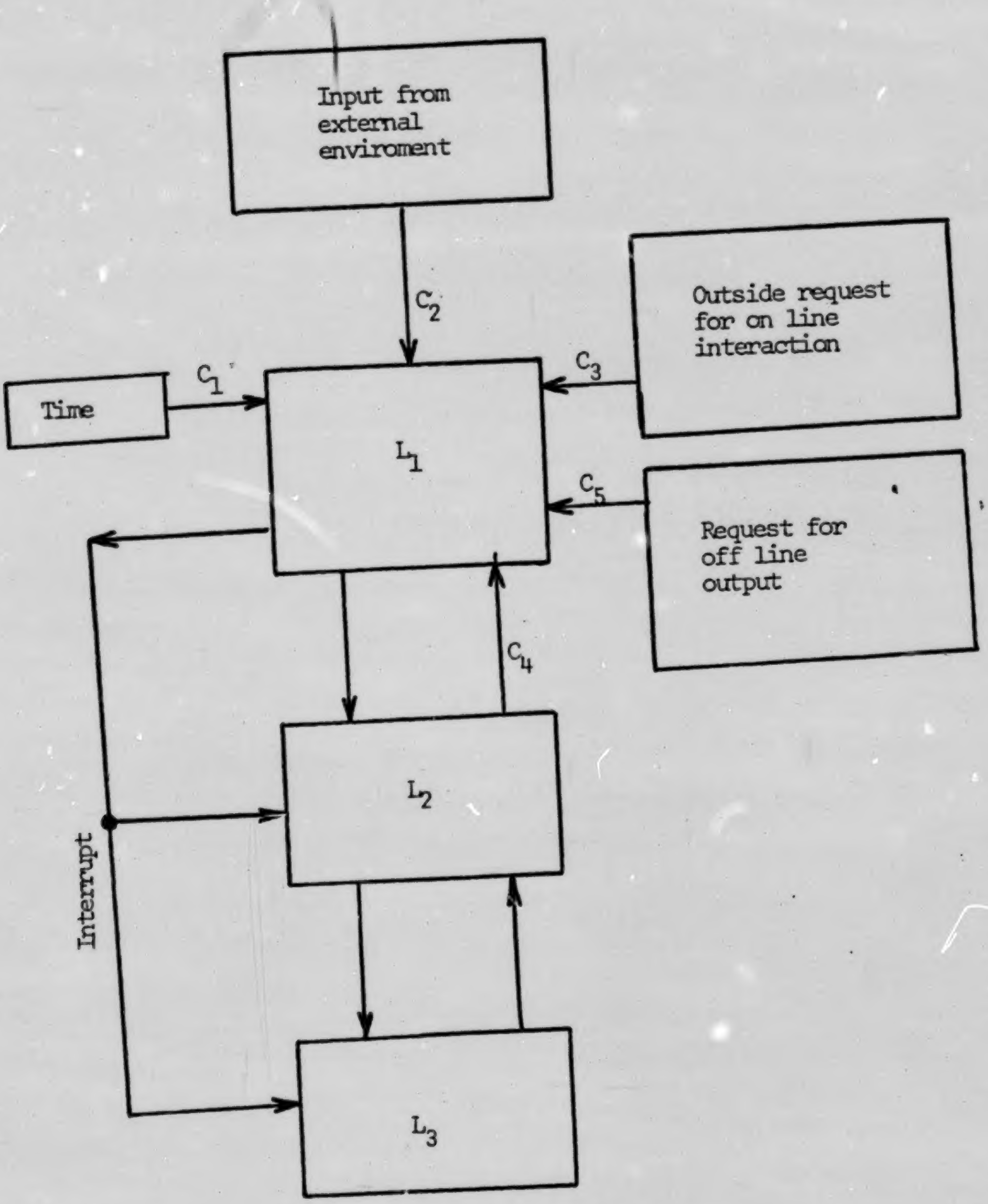

Input from
external
enviroment
C_2
Outside request
for on line
interaction
C_3
Time
C_1
L_1
C_5
Request for
off line
output
C_4
L_2
Interrupt
L_3

Fig. 12

3.2 Levels

From the preceding description, a three level control system for STITE is envisioned. It will comprise mixed features of computer timesharing, multiprogramming and operating system.

3.2.1 Level L_1: Processing of general conditions (GCCH) that are:
- internal change (clock), C_1
- external change (new-input), C_2
- interaction asked for from outside, C_3
- Interaction asked for from inside, C_4
- request for of line output, C_5

Level 1 brings the system into one of 32 states S_m ($m=1\ldots2^5$) where for each of them it will have to be decided what the corresponding activity of L1 should be (i.e., if 2 and 3 conditions occur at the same time, which one should be processed first or differently than if it occurs alone, etc.)

3.2.2 Level L_2: It is assumed that one activity of Q can be processed at a time. This is very likely true if the STITE system is a centralized system with one computer.

It is anticipated, however, that the assumption depends on the design of the system, where common Q can be created for more centralized or decentralized computers. Separate Q's for each decentralized site is also likely. Our level 2 description is therefore more to convey basic ideas of the design approach than to make the decision on the concept at this time.

Level L_2 may consist of a simple or a more sophisticated operating system node in which activities stored in Q are retrieved, based on a convenient criteria (priority, operational characteristics recognized for that activity, other criteria), and processed. The condition of Q creates an empty or a busy signal as a condition C4 for level L_1.

A simplified flowchart for level 2 operation appears in Fig. 13.

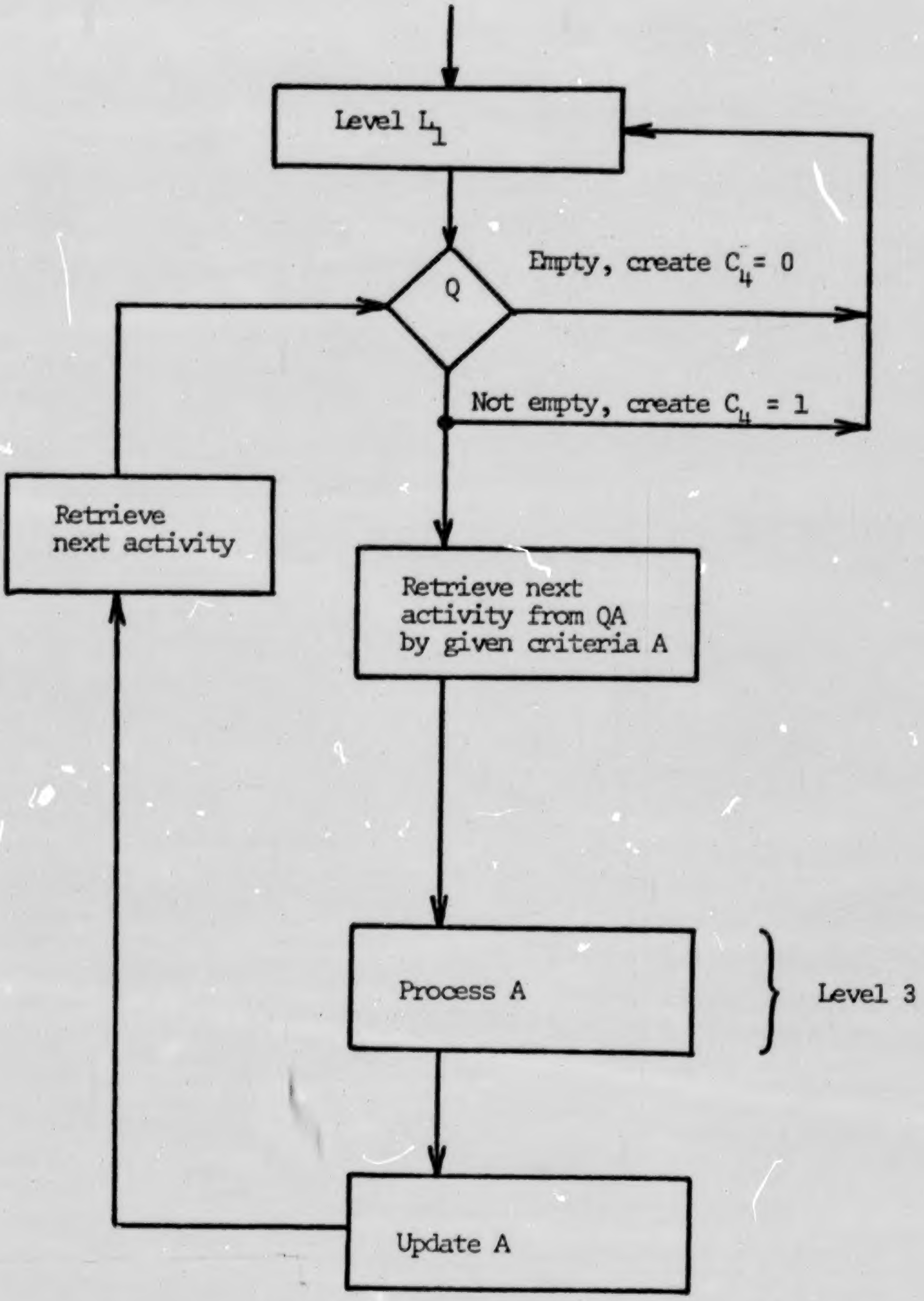

Level L_1
Q
Empty, create $C_4 = 0$
Not empty, create $C_4 = 1$
Retrieve next activity
Retrieve next activity from QA by given criteria A
Process A
Level 3
Update A

Fig. 13

3.2.3 Level L_3: Level L_3 operation consists of the activities shown on Fig. 3.

- -preparation of the preparation of the program P_A from internal library subprograms
- -processing of P_A
- -recording the location of generated data for the corresponding request R_A
- -Generating new requests for activities that do not occur among the scheduled activities of the request (internal to the library subprograms, i.e. if such subprograms has been used that requires additional activity) and inserting them into Q, if the new activity is to be handled by STITE or into external Q called EXQA if the activity is to be performed as external to STITE e.g. request for additional information to an outside information center, where EXQA is a file for outside off-line communication.

3.3 Comparison with Existing Concepts.

In comparison with existing concepts in computer systems, a loose parallel of the activities of the STITE system can be drawn as follows:

- -Level 1 = similar to a time sharing concept
- -Level 2 = similar to an operation system concept
- -Level 3 = use of the concepts of automated programming, possible multiprogramming for better effectiveness in case STITE should become a large system.

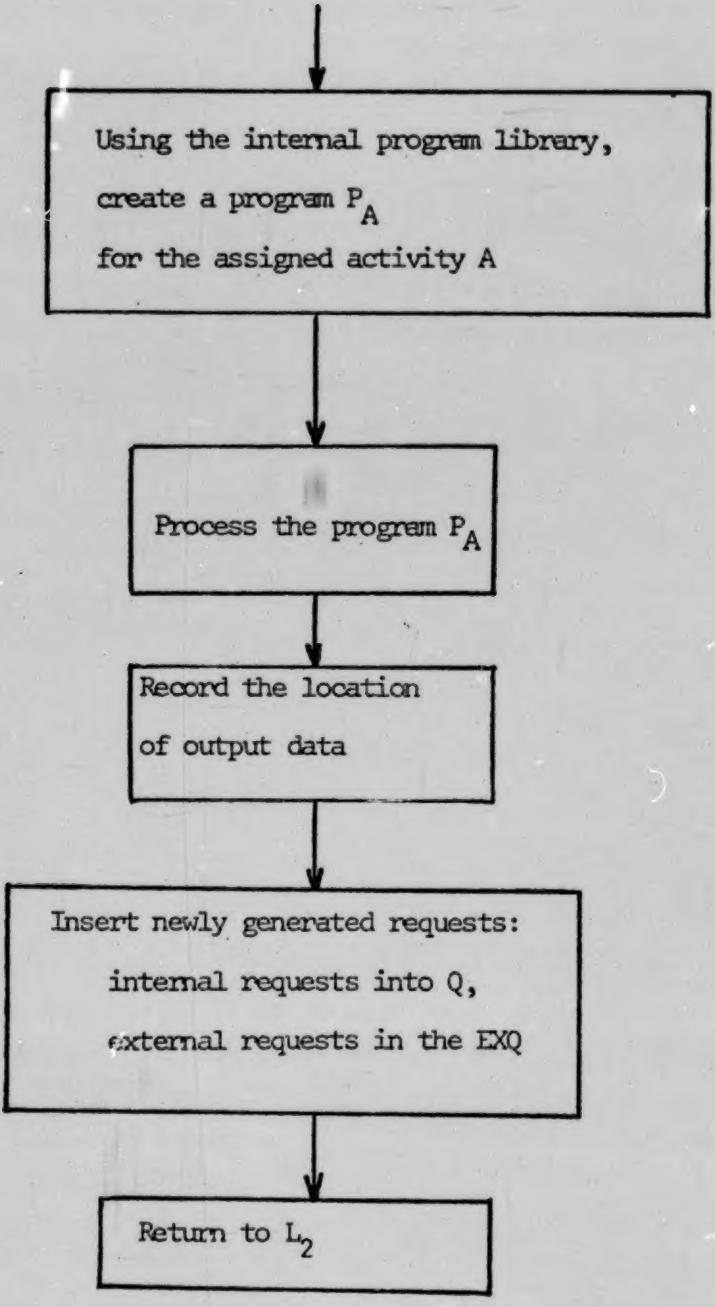

Using the internal program library, create a program P_A for the assigned activity A
Process the program P_A
Record the location of output data
Insert newly generated requests: internal requests into Q, external requests in the EXQ
Return to L_2

Fig. 14

IV. DESIGN CONCEPTS OF STITE SYSTEM

The design concept of STITE refers to the way in which units of the system, such as terminals, processors, various types of memories, and its own data banks are distributed over the geographic area involved. It has been assumed from the beginning that the geographic area covered by the system will be hundreds of miles in node-to-node distances, rather than all units being placed in the same town or even in the same building.

When such a large geographic area is to be covered by a relatively large system, problems arising from distances involved have to be resolved. For example, what type of communication will be used and what will be the best network for that communication and what will be the best distribution of units over the nodes of the network?.

There are three main parts that need to be recognized in design:

-the units of the system

-communication network of the system

-distribution of the units over the nodes of the network

1. Units of the STITE system

It is useful to recognize two types of units that are directly part of the STITE system. First, there are internal units of STITE, being recognized as units that are controlled, served, or are, in a broader sense, under the administration of STITE. Secondly, there are units that are sources of information for STITE, such as information centers, that are not, however, under direct control of STITE. They are called external units of STITE.

1.1 Examples of Internal Units

1.1.1 Terminals - "Terminal unit of STITE" is the term which will be used in as broad a sense as possible to mean units interfacing between STITE and its environment. The following will serve to illustrate the wide variety in each sub-category.

-common computer terminal - keyboard, card reader, or card punching machines, printer, paper or magnetic tape.

-less usual computer terminal - plotter, TV camera, cathode ray tub display, digital display, light pin.

- -possible terminals of near future - voice input and output, color TV, remote handwriting.
- -scaled instruments and indicators - measuring panel instruments, various meters, controlling lights, osciloscope.
- -manually operated devices - picture transmitting devices, cameras, films, projectors.
- -final receiver or original source of information processed by STITE - clerk, laborer, instructor, educator.

1.1.2 Processors - The following are examples of processors, all of which can participate in information processing, transmitting, reformating, on-line remote demonstrations, live simulations under the control of a remote site:

- -central processor of large computer
- -mini computer
- -computing center
- -analog computer (e.g. deferential analysor)
- -caning device for multi instrument panel
- -special computers
- -simulators

1.1.3 Storages - Various types of computer storages, memories and internal data banks.

1.2 Categories and Examples of External Units of STITE

While the geographic location of external units is given, there are the internal units of the system that have to be decided upon by the design. Some of the internal units will have to share the same place with external units. They are mostly terminals. Others, like processors and internal data banks, need not, and it is the role of the design concept to decide about their most effective location.

1.2.1 Information Centers - The second type of unit is called external units. They are units that interface the system by supplying requests and STITE data from external data banks, information centers, libraries and other sources of information for STITE. In a broad sense they are the environment of the system. They interact with STITE however they are not under the direct control or under the administration of the system.

1.2.2 Educational Institutions - Educators, schools, school systems, colleges, universities and other centers of education (to which information is being transferred via STITE).

2. Communication Network of STITE

From the beginning it is very clear that there is no need to design the communication lines between the nodes of the system. Existing communication lines, such as telephone lines, and TV networks, are and will be sufficient for use in STITE. It is accepted that STITE will operate on whatever communication network is or will be available in future, rather than necessitating the design and implementation of its own communication lines. This approach is being used by many other existing geographically wide-spread systems like large company communication networks, computer-communication networks, and education communication networks.

From the designing point of view of STITE, it has to be indeed kept in mind that communication lines with improved communication characteristics are certainly possible and that the design of STITE has to provide room for such future improvements as they become available. For example, more and more effective TV lines via satellites and laser beams or laser beam telephone channels are just two of the ways of communication that will have an impact on future communication networks. STITE system has to be designed in such a way that it will be ready to absorb such impacts rather than ignore them.

On the other hand, STITE is essentially a computer system. As such, it will very likely not face any impact of future technology of communication in isolation. It will rather follow the same paths that will be followed by other computer communication networks and it will utilize and adapt to whatever will be offered as feasible continuation.

For these reasons, no special attention will be given in STITE research to the direct problems of communication lines except for the economy of the use of already existing lines. It is rather the distribution of the internal units over the nodes of the communication network that will be the center of research interest.

3. Distribution of Units Over the Nodes of the Network

3.1 Distribution of Nodes

There are many ways in which a system can be analyzed, designed or viewed as a system of nodes. Among them are:

- geographic location of the units or groups of units of a system - The nodes are then described as configuration of the units that are placed at the same location, i.e. in the same room, or in the same building, on the same campus, in the same city, in the same region. Geographic location is important primarily for the communication networks, maintenance of the system, and communication costs.
- functional viewpoint - The nodes of the system are grouped according to their role in the system. Units of the system belonging to certain nodes participate in the same engagement, regardless of their geographic location.
- administration viewpoint - The units of the system are arranged into nodes or groups according to criteria such as financial supervision of the system, charging structure for services, paying for outside information, and paying for manpower associated with the system.

Traditionally it seems to be desirable to unify the above three viewpoints and create the node with units in the same location performing the same functions and being considered as one unit administratively also. This approach, however, is not necessarily them most economical or best approach from the standpoint of some other criteria. For example, if expertise using more than one person is required and each of them lives at different locations, their terminals can be connected to the same computer where both of them can contribute to the same function. On the other hand, the same person can function in one capacity in one location while in another, different capacity he can regularly contribute to the problems being solved at another location.

Thus, communication allows participation by a person in remote activities without the need for relocation of the person. It is then the type of function in which the person is involved that is more important to b recognized than the actual location of the person himself or the site for which the service is being granted.

Use of computers in large systems, however, does not always complicate the situation. It enables the entire system to track and record internal activities, including information comprising who is involved in certain activities (i.e. what person, what group of persons, what nodes of the system, what programs, the extent of the involvement) and in what capacity the involvement is being made. Providing this and other types of information and being implemented on sound design, the system becomes a highly dynamic entity involved in its servicing function with many progressive features. It need not to be limited to particular geographic locations. It can be properly administered because the administrative structure, based on the administrative viewpoint can freely be imposed on the existing system and easily adapted later if the growth of the system requires it. Functional structure can be made, matching the adminstrative structure in one extreme or being dissociated from it in the other and grouping the system units can be mutually independent by infrastructures.

New dimensions can be given to systems in terms of flexibility in adaptation of its infrastructures to changes, anticipated or unanticipated, in the growth of the system and in constantly augmenting the power of the system by adding new features. Flexibility in reallocation of the control of the system may range from localized to centralized controlling function or vice versa, and charging structures, management problems, and other administrative manipulations can be flexible. Provision can also be made for flexibility in responsiveness to the needs of the system customers, and in the introduction of innovative approaches.

3.2 Design of the System Nodes

It is primarily the functional aspect that will be in the center of attention of project STITE research. Studies of the functional nodes and their tentative design will help to formulate conditions, specifications, and operational characteristics for both refinement of the design and for implementation of STITE.

Once it is decided what the functional nodes of the system will be, the next step will be to decide where the activities related to that function will be implemented. Three possible alternatives will be examined:

- centralized system - All function performed at one selected location
- decentralized system - Basically the same function can be performed at different geographic locations.
- dynamic system - There is no specific place where certain functions must be performed. It is under the internal management of the system that the location of functions is changed under certain conditions. If a function is used the system will direct the corresponding data to the site that is in charge of that function at that time. (The whole STITE system acts in a fashion similar to a large operating system involving many computers and/or centers.)

The following illustration sketches the described situation as a Q that collects all requests from the input and places them into QA in a line, where they wait for processing. When retrieved from Q, they are processed for allocation to the proper place for further processing.

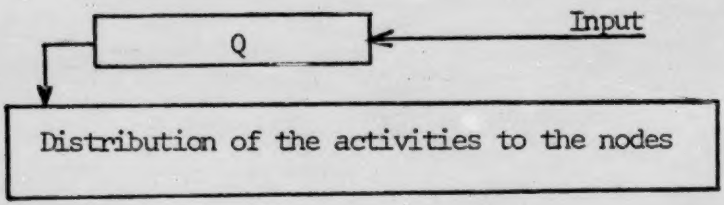


Fig. 15

3.2.1 Centralized Q - Jobs such a customer requests, required sub-activities and interface with information centers will be collected in Q. Then they will be distributed to other units or nodes of STITE that in turn will feed back the information about finished activities and also signals indicating that they are ready for an additional load or that they are still busy. It is, however, the central part of STITE that continually keeps track of out-put data of each activity and collects all data back into the center.

3.2.2 Decentralized - Jobs are collected in a different Q of local character or grouped in different Q's according to the character of the required activity or some other convenient criteria. From there, jobs will be sent to the facilities servicing the corresponding Q.

3.2.3 Bidding System - This system is a reversed concept of centralized control. The center collects only the jobs and makes available a list of the jobs to processing nodes of the system. The nodes send conditions or bids under which they can process the jobs. The idea is that the subcenters or processing nodes are in competition to provide better service. This would enhance improvement and economy of the system. Bidding system is a new concept for the design and will be considered in research in much more detail.

PART FIVE

LITERATURE SURVEY

PART FIVE

LITERATURE SURVEY

I. INTRODUCTION

The STITE project proposal states that the design of the descriptive model will be preceded by "a review of the relevant research literature on the systems approach to curriculum development." The purpose of such a review will be to identify and evaluate developments and research that have already been conducted in this field and to determine their usefulness in the design of the STITE system.

The subject range of the project will be delineated in terms of topics and categories, and then appropriate indexes, reports, and other publications will be searched to identify and evaluate those materials which are significant for the goals of the STITE project.

Finally, a bibliography of relevant literature will be compiled.

II. SCOPE OF THE LITERATURE SURVEY

The purpose of the STITE project is to study, design, and evaluate a system for the transfer of science information from its present repositories into a science learning system. The scope of the project can logically be divided into three parts then.

First, there must be an identification and an analysis of existing centers and systems in terms of the subjects they include, their operating characteristics and the ways in which they are used.

Secondly, there will follow a definition and description of learning tools and systems, and an analysis of the methodology involved in designing them, as well as some evaluation of their usefulness with respect to the objectives of the STITE project.

Thirdly, there must be some consideration of information transfer systems and networks to determine their significance for the design of the proposed transfer system.

The subject scope of the literature search will follow the three aforementioned divisions, i.e., science and technical information centers, learning systems, and information transfer systems and networks. Initially, spot checks for relevant references were made within the designated subject areas, and this preliminary and tentative outline of the survey, with some random references, has been developed. It will be expanded and refined with future investigation.

III. SCIENCE AND TECHNICAL INFORMATION CENTERS/SYSTEMS

The collection, organization and dissemination of descriptive information and bibliographic data comprises the so-called "science information system" whose services typify the current level of the information industry -- the establishment of computerized information utilities and services of different types and purposes. According to Bushnell, it is not mere speculation to anticipate the day when information acquired during the operation of the central information processing service feeds directly into decision mechanisms that regulate the scheduling and instructional programs of the educational institution.

1. CLASSIFICATION OF SCIENCE AND TECHNICAL CENTERS/SYSTEMS

1.1 On the basis of subjects - This classification of science information systems will determine which centers are to be accessed for development of new courses in a given subject area, and it will also facilitate the identification of centers capable of providing the necessary science information for updating learning materials or for modifying course preparation in a given subject area.

Cohan [Ref. 1], gives the description of each science and technical information repository and each information storage and retrieval system; he also states types of output and service available to the user community, user equipment requirements, user restrictions and subject coverage. Palmer [Ref. 6], has done almost the same thing as Cohan has done, but he gives little description of the systems. Kruzas [Ref. 5], gives information resources available in the U.S. in the Directory of Information Resources in the U.S. [Ref. 2], and points out the holding of information in each center under subject coverage.

1.2 On the basis of operating characteristics - There is a wide variation of automation among information centers. Some have computer based data-banks. Others have computerized networks and represent cooperative efforts to share resources of provided information on a multi-unit basis.

2. ANALYSIS OF SCIENCE AND TECHNICAL INFORMATION CENTERS FROM THE VIEW POINT OF DESIGN OF SCIENCE INFORMATION TRANSFER SYSTEM

This analysis will include descriptive details of the data bases, information retrieval and communication, organization of information, information control, user study and in what forms information is presented to the user.

These topics will be helpful in determining the methodology to be used in identifying the design criteria for the science information transfer system. It also indicates the limitations of data base, retrieval system, and subject area coverage of science information transfer systems.

Lesher and Nowick [Ref. 3], point out how NASA technical information can be transferred/accessed. Doctors [Ref. 2], describes the NASA technology transfer program. In his article, the roles of federal agencies are well defined.. The design of STITE would benefit from the contents of these two articles.

Sparks [Ref. 7], gives a methodology for the analysis of information systems. Gruber, and Marquis [Ref. 2], point out human factors and limitations in the transfer of technology. North American Aviation, Inc.[Ref. provides an analysis of scientific and technical information requirements of FAA. Nay [Ref. 5], presents the development of a resource information bank for teaching science. These four articles provide a clear review of how STICs operate.

Simpson [Ref. 8], makes the observation that scientists and engineers have solved their wordage and most other information problems through the creation and use of information analysis centers (IAC). IAC's synthesize, analyze, and compress pertinent information so that knowledge transfer remains effective. STITE can help in transferring knowledge more effectively from IAC to users.

Libaw [Ref. 4], presents a new, generalized model for information transfer that has at its heart a machine-readable record. The model points out how the core machine-readable record makes possible interfacing computer typesetting with advanced information technology, the interfacing of primary with secondary publications, and the interfacing of data with document information systems. His model would help in the design of STITE.

Thuronji and Pictkiewicz [Ref. 6], show how the principal users of a small information system are built into the system and how the feedback received from them improves the system, especially in the areas of document selection, indexing and bibliographic format.

Raizada [Ref. 3], attempts to analyze the concept of "user acceptability". The factors affecting this are the physical presentation of information and the semantic contents of the information in the computer printouts. Study of "user acceptability" would make STITE more practical and satisfactory.

Saha [Ref. 4], points out that to ensure that the need for information is satisfied, user studies are necessary at intervals to determine if the information system as designed and operated does the job efficiently and economically for the reader community it serves. For this purpose the organization handling the information must identify specific information services, study reader's habits and communication modes in a particular environment, and then focus on the problem areas for desirable solutions. STITE would benefit from Saha's conclusions.

Kreysa [Ref. 1], makes the observation that the Smithsonian Science Information Exchange (SSIE), after expanding its coverage of subject matter and changing in administrative or fiscal structure, can facilitate more effective planning, management, and coordination of the scientific research and development sponsored or supported by U.S. government agencies. STITE should be able to do what SSIE has done.

Lipsitz [Ref. 2], describes how ten thousand homes can be tied to a computer center and how they can fully utilize the information and facilities of the computer center. These ten thousand homes could be users of STITE in the future.

Veazie and Connolly [Ref. 6], point out where information analysis center products go and identify the users who benefit from the services.

IV. ANALYSIS AND DESIGN OF SCIENCE INFORMATION TRANSFER SYSTEMS

A science information transfer system is a bridge between science and technical information centers and science learning systems. In other words, it transfers valuable information, upon a user's request, from data banks in science and technical information centers into science learning systems.

1. Man-Machine Interface With Respect to Science Information Transfer System

1.1 Question and Answering System - A question and answering system provides a questionaire for user to answer. It analyses his answers to determine his area of interest, the kind of information he is seeking and his objectives. Then this system will decide either to ask more questions in order to understand the user's intention more clearly or to supply the information requested, It may even suggest that the user use a particular learning system with a guide, so that the user can improve his work. A science information transfer system that is going to help a user from a certain background must first acquire data from the user, and then through certain procedures, find ways to help the user.

1.2 Editor Program - An editor program provides a means for manipulating the text of a named file on a named file on a micro tape or in the user area of the drum (corresponding to micro tape). This file may be used for the creation of text or for later use as data or as a program to be translated by the FORTRAN Compiler, etc. The commands provide for the editor to allow text to be created, deleted, or moved about. The content of science and technology is changing and enlarging everyday, and so is the information stored in science and technical information centers. The science information transfer system must be able to update its own data files accordingly by using a fast and efficient editor program.

1.3 Display and Input, Output Devices - A display is a visible representation of data on a console screen in a printed report, graph, or drawing, subject to alteration by a light pen or "stylus."

An input device is the mechanical unit designed to bring data to be processed into a computer, e.g., a card reader, a tape reader, or a key board..

Input to the computer can take a variety of forms: punched cards, punched paper tape, magnetic tape, magnetic cards, magnetic ink, or directly and binary form from the core memory or peripheral storage units and various conversion units. Quite recently, plain typed print or script in limited vocabularies became serviceable as input to computers. Input is also developed photoelectrically (scanners) and through the use of TV-type cathode-ray-tubes. Audio input is also being perfected with limited vocubulary. Direct input can be developed by telephone, teletype and numerous other communication devices besides the cards, tapes, inks, scanners, and CRTs previously mentioned. Proper input devices for the project's system must be found.

An output device is the part of a machine that translates the electrical impulses representing data processed by the machine into permanent results such as printed forms, punched cards, and magnetic writing on tape..

Data can be written out from storage to output units, or it can be read from storage to output. The results of the processing are thus converted to English or decimals. They can be recorded in various ways - as a printed report; as graphs, drawings, or language for viewing and altering on display tubes; as magnetic tape, paper tape, punched or magnetic cards; or as audio output. Some very dramatic innovations of computer systems concern the newest optic devices and automatic-language for viewing and altering on display tubes; as magnetic tape, paper tape, punched or magnetic cards; or as audio output. Some very dramatic innovations of computer systems concern the newest optic devices and automatic-language translators (example, Russian-to-English) as well as talking machines and adaptive processors. To find the proper output devices for the project's system is also necessary.

1.4 Intelligent Terminal: An intelligent terminal is a unit that is programmable by the user in much the same way that a conventional computer can be programmed. It has a stored-program unit to handle some processing independently of the central processor. Intelligent terminals can offer the user the opportunity of reducing costs by doing some processing locally, providing more effective data entry techniques and compressing data for faster and more economical data transmission. Greater flexibility is possible since most intelligent terminals can emulate other terminals and can handle a wide variety of applications. Through the use of remote consoles, joint utilization of identical data files for research and planning and student, as well as faculty, instruction become possible. Inclusion of "the terminal that thinks for itself" to the project's system would also be desirable.

Literature on the topic, Man-Machine Interface with Respect to Science Information Transfer Systems, will include the following references:

Green and others [Ref. 10],describe"Baseball: An Automatic Question-Answer Game." Their ideas may be useful in the design of a question and answering system needed in STITE.

Botterill [Ref. 4], presents the design objectives for the Multiple Terminal Monitor Task, running under OS/MVT, a description of the system, the services provided, and performance on a model 65. Bryden [Ref. 6], describes the major types of CRT display systems, along with the techniques used, the types of hardware, and human engineering considerations. He also gives specification tables for the major alphanumeric and line-drawing devices available. Scherr [Ref. 18], covers all aspects of display system design, including optics, photography, device characteristics, measurements, and human factors. Stover [Ref. 19], gives the description of a unique display capable of true three dimensional, full color displays. The system is based on concepts of lenticular optics and does not use auxiliary viewing aids. These articles will help in choosing the right display system for STITE.

Rubin [Ref. 17], covers source data automation, key tape devices, OCR, voice response, digital plotters, and display devices. He also demonstrates the application of each type of I/O device. Murphy provides a basic introduction to the various types of prints, plus characteristics and product descriptions of satellite printing systems.

Auerbach On Alphanumerical Display Equipment [Ref. 1], provides a basic introduction and description of alphanumeric display equipment. Frank [Ref. 7], reviews the availability and use of portable terminals. "Graphic Terminals" [Ref. 9], describes in simple terms the operation of graphics display systems and the different types of systems available. *High Reliability Marks Thermal-Printing Terminals* [Ref. 10], states that reliability and low noise levels are two of the advantages offered by thermal printing terminals.

Murphy [Ref. 14], covers both alphanumeric and graphic CRT terminals, and he also reviews terminal types, their operation, the market, and available literature.

Intelligent Terminals [Ref. 12], illustrates the use of intelligent terminals and discusses three specific terminals, the concept of distributed intelligence, the application of intelligent terminals, and costs and problems and reviewed. McGovern [Ref. 13], gives the definitions of different types of intelligent terminals and discusses IBM's role in this area, along with comments on future directions. Bairston [Ref. 2], makes the observation that stand-alone computing, data entry, and remote batch processing are all possible with a comprehensive intelligent terminal. To facilitate STITE with intelligent terminials seems to be a necessity.

Brooks [Ref. 5], describes Oliver's experiment, that of using a computer graphic system for teaching numerical analysis, and Johnson's experiment, that of computer-administered instruction in teaching PL/I. He also concludes that the use of computer graphics appears to be more promising for college teaching application than conventional CAI, where weaker effects have so far been found. Graphic outputs on CRT terminals could occur frequently while accessing STITE.

Van Dain [Ref. 20], discusses display technology in detail and gives examples of promising man/machine interaction experiments.

Hill [Ref. 11], gives reasons for requiring a man-machine interface using speech, and outlines speech production and perception. He also discusses speech recognition and some applications. Conversational ability of man-machine interface in STITE is worth of study.

"New Printer Copies Computer Displays [Ref. 16], describes the new electrostatic page printer introduced by SE Computer Peripherals. It provides a copy of the data displayed on the computer video terminal in only 3 seconds.

2. Intercomputer Communication/Computer Network

A Computer Network is two or more interconnected computers. It permits geographical distribution of computer capability to meet local information processing needs and at the same time permits local available capacity to meet requirements from remote locations that are unable to handle local needs. Data and programs can be transmitted around the network. For information storage and retrieval systems, a network of computers permits multipoint entry, query analysis, locally maintained data banks, availability of local data banks to all stations of the network, use of common languages, central control points or information switching centers, and mutual support activities, such as rapid data transfer, immediate response, reduced interference with local mission, and a reduced necessity for new centralized facilities.

Brewster [Ref. 1], defines the task of planning a communication network and discusses a program called NETSET to aid in optimizing the network design. Kleinrock [Ref. 6], discusses mathematical modeling, analysis, and stimulation in their role as tools for creating the design for a computer network.

Computer Network Measurements: Techniques and Experiments [Ref. 2], gives the development of measurement capabilities for the ARPA network and the utilization of these capabilities to create analytic models of network behavior. Harris [Ref. 4], discusses developments for the on-line system of the ARPA network, including reduction of core requirements, improvements to the internal scheduling algorithms, and the development of a multi-line controller. Herzog [Ref. 5], reports the activities of the MERIT computer network, and describes communications hardware, telephone facilities, and software systems.

Computer Network Research [Ref. 3], points out modeling, analysis, measurements and systems software for computer networks. Marill and Cureuritz

[Ref. 7], present an analysis of the technical problem of data handling within a computer communication network.

Walden [Ref. 10], presents a system of communication between processes distributed throughout a computer network.

Roberts and Wessler [Ref. 9], describe the need for a computer network, the requirements of a computer communication system, and the potential uses of a computer network.

McCann [Ref. 8], gives the general nature of networks: advantages, configurations, transmission speeds, costs and media. He also describes the planning for a national on-line medical bibliographic service, including network alternatives, decentralization versus communications, costs, and selection from alternatives. These references would help in designing a computer network in the STITF system.

3. System Safety Security

3.1 File Protection - A device or method that prevents accidental erasure of operative data on magnetic tape reels.

3.2 Memory Protection - A specifically design method of insuring that the contents of main memory, within certain designated but variable bounds, will not be destroyed or altered. Special programming devices or hardware thus guard against the effects of equipment malfunction and program bugs in real-time systems.

Study in the area of Safety-System/Security is necessary, for security is an important element in a computer-aided system.

"A Brief History of Computer Privacy/Security Research at Rand" [Ref. 1], provides a review of RAND Corporation research on computer security and the protection of data in the computer system from unauthorized access. Graham [Ref. 7], points out the technical aspects of protection and the procedures which govern the access of executing programs to various resources in the system. Turn and Shapiro [Ref. 14], discuss the problem of cost effective data security safeguards in personal information data banks. Friedman [Ref. 6], reviews the problem of protecting proprietary data in large computer files in a system which permits the sharing of data.

Boruch [Ref. 2], outlines a number of distinctive methods for assuring the confidentiality of data and relates them to security-oriented information processing activities. Conway and others [Ref. 4], discuss record selection, field security, restriction of processing operations, and system implementation. Donn [Ref. 5], describes a pseudo-random binary sequence-generating shift register for scambling digital signals. Hawkins [Ref. 8], considers software control of system access, security of the operating system and protection against malfunctions.

Leavitt [Ref. 9], explains how data compression techniques can contribute to data security as well as improve system performance. Leavitt [Ref. 10], discusses the use and effectiveness of passwords as security devices over programs and data. Peck [Ref. 11], reviews access controls, internal system controls, data transmission controls, and potential and actual violation controls. Reider [Ref. 12], presents some of the elements of a sound control and security plan for computer records. Smith and others [Ref. 13], use both software and special hardware to provide enciphering and deciphering of messages between a terminal and a computer to provide protecting of data in transit and in storage.

Anderson [Ref. 2], points out problems concerning computer security, problems of file protection, and communication problems. He also discusses techniques of system access control, operating system functions, techniques of file protection, and techniques of security assurance.

4. Large Memories - Associative Memory is a storage device in which the storage locations are identified by their contents rather than by their names, addresses, or relative positions. The associative memory is capable of being interrogated in parallel fashion throughout its entire contents to determine whether or not a given word is stored by directly comparing it with all words stored without regard for addressing. The associative memory can quickly answer the question, "Is this word contained in memory?' The concept reduces address bookkeeping, since the keys serve as addresses.

Large Auxiliary Memory is a large storage device in addition to the main storage of a computer; e.g., magnetic tape, or magnetic drum. Auxiliary storage usually holds much larger amounts of information than the main storage, and the information is accessible less rapidly.

The internal hierarchy of memories must be studied in detail in order to use the primary core memory, the associative memory, and the large auxiliary memory effectively.

5. Information Access

5.1 Immediate Access - The ability to directly obtain data from, or to place data in, a storage device or register, without serial delay due to other units of data and usually in a relatively short period of time.

5.2 Parallel Access - The process of obtaining information in storage, where the time required for such access is dependent on the simultaneous transfer of all elements of a word from a given storage location. Since the science information transfer system will undoubtedly be concerned with frequent information accessed in small or large amounts, information access methods must be considered. Both immediate access and parallel access have advantages, and using them interwovenly will give maximum efficiency.

Dell [Ref. 1], provides a readable account of a laser mass memory system with trillion-bit on-line capacity and fast access. Gentile and Lucas [Ref. 2], point out that TABLON is a network of dedicated computers, special hardware, and mass storage devices which any user CPU can access for storage and retrieval of dates. TABLON was developed to provide common data base capabilities to dissimilar systems and to reduce the cost, space, and administration of larger magnetic tape libraries. Label [Ref. 6], describes the major features of the different types of auxiliary storage devices and give selection criteria. Gross [Ref. 3], defines the ultra-larger digital storage system and establishes a boundary between these and large storage systems. Harker [Ref. 4], surveys the historical development of magnetic disks for bulk storage applications, covering hardware capabilities, device characteristics, some alternative technologies, and past and future hierarchies.

Penny and others [Ref. 7], discuss the design of the mass storage system in use at the Lawrence Radiation Laboratory, consisting of an IBM 1360 photodigital storage system and a CDC 854 disk pack for indices. Katzan [Ref. 5], surveys various storage hierarchy systems and gives a state-of-the art analysis covering basic storage hierarchy concepts, addressable storage, storage management, and data organization and management.

6. Information Retrieval System

A system for locating and selecting, on demand, certain documents or other graphic records relevant to a given information requirement from a file of such material. Examples of information-retrieval systems are classification indexing and machine searching systems. In order to make the science information transfer system efficient in the area of locating and selecting data from large files, a study of retrieval systems is necessary. The use of a hashing technique to allocate space for overflow records. Under certain conditions this is shown to be superior to the conventional method of chaining. Price [Ref. 9], describes several table hookup techniques, including sequential search, merge search binary search, estimated entry, and direct entry.

Bennett [Ref. 1], states that the Negotiated Search Facility (NSF) makes possible index-controlled retrieval of information from a collection data base using tools beyond those available in a traditional bibliographic catalog.

Back [Ref. 1], reviews studies of information dissemination as a basis for determining how on-line retrieval can best compete with a multitude of other sources of references and presents criteria that the system should satisfy to be as widely used and as comprehensive as other reference retrieval methods. Barber [Ref. 2], states the principles upon which the Technical Indexes system was based, with particular reference to the advantages of microfilm, and discusses the factors involved in the design of the retrieval system. Hoffman [Ref. 4], introduces a large-scale information retrieval system developed for processing DuPont information files. The use of threaded lists, in addition to inverted files, to permit optimum searching is a very important feature.

Jardine and Van Rijsbergen [Ref. 5], introduce information retrieval strategies which are based on automatic hierarchic clustering of documents. They show that cluster-based retrieval strategies are as effective as linear associative retrieval strategies and much more efficient. They also outline how clustered-based retrieval may be extended to large growing document collections. Johnson and Briggs [Ref. 6], make the observation that holography is one of the most promising methods now under research for the achievement of high bulk storage with fast random access at a reasonable cost.

Walston [Ref. 11], discusses the information-storage and retrieval cycle, automatic document indexing and classification, automatic aids to retrieval and dissemination, and automatic fact retrieval and gives types of retrieval.

Williams [Ref. 12], points out that an effective man-machine interactive retrieval system requires a sequence of steps in which man and machine alternately take action. He also introduces an on-line interactive system, Browser, and discusses the objectives of the development of this system.

7. Aspects of Automation of Information System with Respect to the STITE Project

Automation can be defined as the production by devices or machines that are self-acting with respect to predetermined processes; e.g., making automatic the process of moving work from one machine to the next, the theory, art, or technique of making processes self-acting, or the investigation development, or application of procedures toward making automatic the processes of self-movement and self-control.

The aspects of automation of information systems with respect to the project are:

1.1 Abstracting - Searching for the criteria by which human beings judge what should be abstracted from a document as programmed.

1.2 Automatic Checking - Processors are constructed and designed for verification of information transmitted, computed, or stored. The procedure is complete when all processes in the machine are automatically checked, or else the check is considered a partial verification. Partial checking concerns either the number or proportion of the processes that are checked, or the number and proportion of the machine units that are assigned to checking.

1.3 Automatic Coding - A technique by which a machine translates a routine written in a synthetic language into coded machine instructions, e.g., assembling is automatic coding or various techniques and methodology by which a computer is utilized to translate programs from formats which are quick and easy for programmers to produce into formats which are convenient and efficient for the computer to execute.

1.4 Automatic Error-Correction - A technique, usually requiring the use of special codes and/or automatic retransmission, that detects and corrects errors occuring in transmission. The degree of correction depends upon coding and equipment configuration.

1.5 Automatic Programming - A technique by which a machine converts the definition of the solution of the problem into a series of ordered procedures and operations that can be automatically coded, or the method or technique whereby the computer itself is used to transform or translate programming from a language or form that is easy for a human being to produce, into a language that is efficient for the computer to carry out. Examples of automatic programming are compiling, assembling, and interpretive routines.

Correcting Codes for Exchange of Information Between Computers [Ref. 2], proposes two codes which are comparatively easy to implement by means of computer programs and which correct arbitrary errors in a machine word and one or two adjacent words. Harding [Ref. 6], develops a table set of performance equations for error detecting and correcting codes in a random-error-environment.

Lignos [Ref. 7], suggests an approach to selecting a burst error correcting code and describes its hardware implementation. Wallner [Ref. 10], reviews parity checking schemes for magnetic tape, disk, and drum devices.

Douglas [Ref. 3], presents computer monitoring of assembly processes as means of achieving better management control over production operations.

Rush and other [Ref. 8], report on the development of techniques for the automatic production of high quality abstracts from the full text of the original document. The most significant contribution of this paper is the point that an abstract can be produced by rejecting sentences of the original which are irrelevant to the abstract. Methods of sentence selection and rejection are also discussed. Edmundson [Ref. 5], describes new methods of automatically extracting documents for screening purposes. His methods treat not only the presence of high-frequency content words (key words) as one component of sentence significance, but also pragmatic words (cue words), title and leading words, and structural indicators (sentence location). Edmundson and Wyllys [Ref. 4], present a new concept in automatic analysis, the relative-frequency approach to measuring the significance of words, word groups, and sentences.

8. Applications of Computers in Education

Project STITE is concerned with the application of computers as methods of instruction, not with data processing in general. These applications include developments in optical scanning devices, language translation machines, computer-assisted instruction, and rapid document-retrieval systems. The STITE system will definitely be using the computer as the major factor in information transfer.

Braunfeld [Ref. 4], reports on the use of the computer-based PLATO II system to teach a group of undergraduates some topics in computer programming. It appears that the system taught this subject matter effectively. He also discusses economic feasibility and future plans.

Goodlad and others [Ref. 15], gives an overview of education and computer technology, discuss functional areas of computer applications in education, and point out future advances in the field.

Chapman and Carpenter [Ref. 11], say that automation of the instructional process may well revolutionize the field of education. They discuss the broader picture of the research effort in automated tutoring and describe a project on automated tutoring.

Zinn [Ref. 25], provides a framework, a few specific examples, and references to more detailed information concerning instructional uses of computers. He also discusses current problems and the potentials for interactive instruction systems.

Bushnell and Allen [Ref. 8], edit nineteen papers presented in an invitational conference on the present and future role of the digital computer in American education in November, 1965. These papers are divided into 4 groups of interest: 1. individualized instructions and social goals, 2. Computers in instruction and research, 3. Teaching the computer sciences, 4. Information processing for education systems.

Bushnell [Ref. 7], presents a computer based teaching system that is being tested at System Development Corporation (SDC) to make teaching more effective. Bushnell [Ref. 6], makes the observation that the on-line use of the computer for teaching mathematics, the sciences, and related subjects is buurgeoning at all levels of education. He also discusses simulations and gaming, new tools for education, information utility, production and evaluation of curriculum materials, and time-shared computer systems.

9. Information Dissemination

The STITE project will be concerned only with the dissemination of educational information. It will be necessary to determine major sources of educational information, the forms in which it is found, how it is disseminated, who uses it, and its cost and effectiveness.

Dumas [Ref. 2], reviews ways and means of disseminating, retrieving, and utilizing research and demonstrating results. Green [Ref. 5], describes how Colorado schools are informed of the use and scope of instructional media and determines the best method of disseminating the information.

Entelek, Inc. [Ref. 3], deals with the establishment and operation of an "Exchange of Information" among universities, corporations, and government agencies concerned with the use of the computer as an aid to the instructional process. Farr [Ref. 4], presents the role of the "Knowledge Linker" and an interpersonal network of communication within a target audience.

Grimes [Ref. 6], describes a regional information system which is designed to provide an effective, systematic methodology for linking users with relevant resources, and gives an overview of the history, structure, and utilization of the information system.

Havre [Ref. 7], identifies, synthesizes, and evaluates shared services of research and development throughout the reaction and presents a model of shared information services to rural educators.

V. LEARNING SYSTEMS AND TOOLS

1. Types of Learning Systems and Learning Tools

Learning systems are broadly defined as technology-aided instruction/ learning facilities which allow learners to interact with organized learning materials stored in an animate, manipulable device or memory.

Learning tools comprise primarily devices and mechanisms for accessing knowledge in science and technology.

Before trying to analyze and design a science information transfer system that transfers science information from its present reprositories into science learning systems, we must study the components and characteristics of the existing learning systems and the learning tools used to determine what and how the science information transfer system can be of help in achieving the objectives of these learning systems using certain learning tools.

1.1 Conventional Learning Systems

-Lecture - A discourse given before an audience expecially for instruction. The learning tools sometimes used in a lecture are: books, paper, pencils, pens, crayons, paints, brushes, blackboard, chalk, musical instruments, athletic equipments, slide rules, overhead projector.

-Seminar - Guided study by a group of advanced students on a particular subject, each student doing some original research, and all exchanging results by informal lectures, reports, and discussions. The tools used: books, paper, pencils, pends, blackboard, chalk, overhead projector.

-Laboratory - A place devoted to experimental study in any branch of natural science or to the application of scientific principles in testing and analysis. The tools used: books, paper, pensils, pens, blackboard, chalk, optical microscopes, telescopes, apparatus of all kinds, electric miscroscope, still cameras, binoculars.

-Demonstration - The act of making known or evident by visible or tangible means, as indication, sign, show, or manifestation.

-Field Trip - Visit to an establishment or institution for purpose of observing activities carried on there. The tools used: public libraries, art galleries, museums, businesses.

-Graphic Materials - Almost any illustrative material can be considered graphic in nature. (Indeed, any printed matter falls, technically, into this category). Graphic materials can also be considered as special material in the audio-visual field. The graphic materials of interest to the project are graphs, charts and diagrams, and pictures. The tools used: paper, pencils, pens, blackboard, chalk, rules, camera.

1.2 Non-Conventional Learning Systems

-Programmed Instruction - According to Shramm, programmed instruction is the kind of learning experience in which a "program" takes the place of a tutor for the students and leads him through a set of specified behaviors designed and sequenced to make it more probable that he will behave in a given desired way in the future. Therefore, programmed instruction is a kind of memory of learning materials used to support the self-instruction process. Tools: four-button machine, new communicator, koncept-o-graph, auto-tutor, computer terminals, computer.

-Computer-Assisted Instruction - CAI is a concept that applies computers specialized input/output display terminals directly to individualized student instruction. The text materials being generated by researchers for instruction are entered into the computer through the use of simplified codes operated for the most part with natural-language inputs. Computer-assisted instruction is obviously a kind of computer application in education, and like programmed instruction, it also is a kind of memory of learning materials to support the self-instruction process. Tools: computers, input/output devices, display, terminals.

-Teaching Machine - According to Fine, the teaching machine is a self-teaching device that helps the student lean faster and in a different way. But the teaching machine is not only a machine. It is also possible to get the same principles from a programmed book. It is what goes into the pages of the book that is important. Experiments show that there is little difference between a "hardware" type of teaching machine and the book type of teaching machine. Both books and machines depend upon programmed instruction to do an adequate job. Tools: multifarious teaching machines.

-Audiovisual Methods and Materials - The principal receptors of information are the eyes and ears, and there exists substantial evidence that many of the factors involved in learning depend on the choice of the receptors employed. An effective learning system thus must be capable of transmitting simultaneously visual and audio information. Such a conjoint transmission is desirable in both skill and cognitive learning. Tools: films, tapes, tape recorders, televisions, film strip projectors (some with sound tracks), movie projectors (with sound), record-player and records, ALF.

2. General Methodology Used for Designing Learning Systems

We will investigate the general methodology of designing learning systems in detail in order to provide criteria for evaluating these learning systems and learning tools.

1.1 Human Interface in Learning Systems - The transfer of information from science information banks to other repositories will proceed via a human interface. In the case of science learning systems such an interface is the author or editor of the stored curricular materials. For example, the preparation and recording of learning materials in ALF is normally carried out by faculty subject specialists.

1.2 General Methodology Used for Designing a Course - By investigating the general methodology used for designing a course, it may be possible to find the steps in this methodology that need help from the science information transfer system.

1.3 Curriculum Development - Curriculum materials are basic to the school experience; texts, films, and workbooks are the mainstays of instruction, especially in the early grades. Until recently the development of these materials followed relatively predictable patterns. Materials were sometimes generated in an ad hoc way by teachers working in the schools, but the major direction of curriculum development generally came from the commercial publishing houses, where the publishers worked on the usual author-editor model. Attention to the development of new courses can reveal the courses that need help from the science information transfer system.

A flow chart describing a general methodology for preparing a course will be developed. In this flow chart it should be possible to identify the steps in which a science information transfer system can be utilized.

1.4 Mental Process of Human Information Transformation - An understanding of the mental processes through which authors of learning materials acquire, evaluate, organize, and integrate new information into the subject matter of existing, organized science curricula will be necessary for the STITE project.

After those key elements of the mental processes are identified, they can be considered in attempts to assist the transfer of science information into education by machine aids.

3. Evaluation of Learning Systems with Respect to Project Objectives

An evaluation of conventional and non-conventional learning systems should reveal those systems which will substantially benefit from a science information transfer system.

VI. REFERENCES

III. CATEGORIES OF SCIENCE AND TECHNICAL INFORMATION CENTERS/SYSTEMS

1. Cohan. L. Directory of Computerized Information in Science and Technology. New York, Science Associates/International Inc., 1968.
2. Herner, S. A Brief Guide to Sources of Scientific and Technical Information. Washington, D.C., Information Resources Press, 1969-1970.
3. Kruzas, Anthony T., ed. Encyclopedia of Information Systems and Services. Ann Arbor, Michigan, Edwards Brothers, 1971.
4. Kruzas, Anthony T., ed., Directory of Special Libraries and Information Centers. Detroit, Mich., Gale Research Co., 1968.
5. Palmer, A. M. Research Centers Directory. Detroit, Michigan, Gale Research Co., 1972.
6. U.S. Library of Congress. Science and Technology Division. National Referral Center. Directory of Information Resources in the U.S. Washington D.C., U.S. Government Printing Office, 1971. 803pp.

VI. REFERENCES

III. 2 ANALYSIS OF SCIENCE AND TECHNICAL INFORMATION CENTERS FROM THE VIEW POINT OF DESIGN OF SCIENCE INFORMATION TRANSFER SYSTEM

1. Doctors, S. I. The NASA Technology Transfer Program - An Evaluation of the Dissemination System. New York: Praeger Publishers, 1971.

2. Gruber, W. H. and D. G. Marquis. Factors in the Transfer of Technology. Cambridge, Mass., The M.I.T. Press, 1969.

3. Lesher, R.L. and G.J. Howick, Accessing Technology Transfer. NASA Sp-5607, 1966. 121 pp.

4. Libaw, F. B. "A New, Generalized Model for Information Transfer: A Systems Approach." American Documentation. 20:381-384 (1969).

5. Nay, M. A., and others, "The Development of a Resources Information Bank for Teaching Science." School Science and Mathematics, 72:284-292(1972.

6. North American Aviation, Inc. Analysis of Scientific and Technical Information Requirements of FAA 1965. AD 651 926.

7. Sparks, D. E. A Methodology for the Analysis of Information Systems. Wakefield, Mass., Information Dynamics Corporation, 1965.

8. Simpson, G. S. Jr, "Information Analysis Center Viewpoint on Wordage Problems: Amount, Languages and Access." Journal of Chemical Documentation, 12: 97-98 (1972).

VI. REFERENCES

IV. SCIENCE AND TECHNICAL INFORMATION CENTERS

1. Kreysa, F. J. "SSIE - An Information Center Which Stores Foresight." Journal of Chemical Documentation. 12:9-12 (1972).

2. Lipsitz, L. "Ten Thousand Homes Tied to Computer Center." Teaching Aids News. 5:5-8 (1965).

3. Raizada, A. S. "User - Acceptability of Information Services Based on Computer Printout." In Users of Documentation. Abstract of papers presented at the FID Congress, Buenos Aires, Sept. 1970 10 p.

4. Saha, J. "User Studies for Evaluation of Information Systems and Library Resources." In Users of Documentation. Abstracts of Papers Presented at the FID Congress, Buenos Aires, Sept. 1970. 7p.

5. Thuronyi, G. T., and W. Pietkiewicz. "User Participation in an Information System," In North, J. B., (ed), The Information Conscious Society. Proceedings of the American Society for Information Science, 7:141-146 (1970.

6. Veazie, W. H., and T. F. Connolly. The Marketing of Information Analysis Centers Products and Services, June. 1971. 33 pp. ED 044 933.

VI. REFERENCES

IV. 1 MAN-MACHINE INTERFACE WITH RESPECT TO A SCIENCE INFORMATION TRANSFER SYSTEM

1. Auerback on Alpha Numerical Display Equipment, Auerbach, 1971. 224 pp.

2. Bairstow, J. N. "The Terminal that Thinks for Itself." Computer Decisions, 5:10-13 (1973)

3. Bennett, W. C. "Buffered Terminals for Data Communications." Telecommunications, 5:46 (1971).

4. Botterill, J. H., and G. F. Heyne. "A General Display Terminal System," Proceedings, Spring Joint Computer Conference, 38:103-11 (1971).

5. Brooks, F. P. Jr. "Computer-Man Communication: Using Computer Graphics in the Instructional Process." Advances in Computers, 10:129-142 (1970).

6. Bryden, J. E. "Visual Display Systems, "Telecommunications, 6:22-26 (1972).

7. Frank, R. A. "Portable Terminals Ease Data Entry," Computer-World, 6:13 (1972).

8. Gaither, R. B., and J. P. Jones, "Man-Machine Interface." Journal of Engineering Education, 62:816-819 (1972).

9. "Graphic Terminals: Man's Window to Interactive Computing." Computer Decisions, 3:10-15 (1971).

10. "High Reliability Marks Thermal - Printing Terminals." Computer World, 6: (1972).

11. Hill, D. R. "Man-Machine Interaction Using Speech" Advances in Computers, 11:166-230 (1971)

12. "Intelligent Terminals." EDP Analyzer, 10:1-13 (1972).

13. McGovern, P. J., ed, "Intelligent Terminals Start Popping Up all Over." EDP Industry Report, 6:1-7(1971).

14. Murphy, J. A., ed, Interactive CRT Display Terminals. Modern Data Services, 1971. Variable Paging.

15. "New Printer Copies Computer Display." Computer News, 16: 3(1972).

16. Rubin, M. L., ed., Handbook of Data Processing Management, Volume IV: Advanced Technology - Input and Output. Auerbach, 1970. 361 pp.

VI. REFERENCES

IV. 2 NETWORKS

1. Brewster, R. L. "Designing Optimum Data Networks." Data Processing Magazine, 13:23-27 (1971)

2. Computer Network Measurements: Techniques and Experiments, NTIS, Oct 1971 360 pp. AD-739 344.

3. Computer Network Research, NTIS, Dec 1971, 156 pp. AD-739 705.

4. Harris, D. O., J. A. Howard., and R. C. Wood. Research in On-Line Computation, NTIS, Sept. 1971, 87 pp. AD-735 300.

5. Herzog, G. Merit Computer Network, May 1971, 67 pp. AD 203 555.

6. Kleinrock, L. "Analytic and Simulated Methods in Computer Network Design." Proceedings, Spring Joint Computer Conference, 36:569-579 (1970).

7. Marill, T., and K. Curewitz. Network Data Handling System, NTIS, Sept. 1971 62 pp. AD-730 724.

8. McCann, D. B. "Networks with Emphasis on Planning an On-Line Bibliographic Access System." Information Storage and Retrieval, 7:271-279 (1971)

9. Roberts, L. G., and B. D. Wessler. "Computer Network Development to Achieve Resource Sharing." Proceedings, Spring Joint Computer Conference, 36:543-549 (1970).

10. Walden, D. C. "A System for Interprocess Communication in a Resource Sharing Computer Network." Communications of the ACM, 15:221-30 (1972.

VI. REFERENCES

IV.3 SECURITY

1. "A Brief History of Computer Privacy/Security Research at RAND." NTIS, Mar. 1972. p. 9 AD-748 917.

2. Anderson, J. P. "Information Security in a Multi-User Computer Environment." *Advances in Computers*, 12:1-36 (1972).

3. Boruch, R. F. "Security of Information Processing - Implications from Social Research." *Proceedings Fall Joint Computer Conference*, 41:425-433(1972).

4. Conway, R., W. Maxwell, and H. Morgan. "Selective Security Capabilities in ASAP- A File Management System," *Proceedings, Spring Joint Computer Conference,* 40:1181-1185(1972).

5. Donn, E. S. "Secure your Digital Data. "*Electrical Engineering*, 31: 5-7 (1972).

6. Friedman, T. D. "The Authorization Problem in Shared Files." *IBM System Journal*, 9:258-280 (1970).

7. Graham, G. S. and P. J. Denning. "Protections - Principles and Practice." *Proceedings Spring Joint Computer Conference*, 40: 417-429 (1972).

8. Hawkins, D. H. "How Safe is Your Software?" *Computer Decisions*, 4:18-20 (1972)

9. Leavitt, D. "Compression Shields Data While Operations Improve." *Computer World*, 6:16 (1972).

10. Leavitt, D. "Passwords Protect Data and Programs," *Computer World,* 6:13 (1972).

11. Peck, P. M. "Data Processing Safeguards." *Journal of Systems Management*, 23:11-17(1972).

12. Reider, H. R. "Safeguarding Computer Records." *Management Control*, 19: 245-248(1972).

13. Smith, J. L., W. A. Notz, and P. R. Osseck. "An Experimental Application of Cryptography to a Remotely Accessed Data System", *Proceedings of the ACM National Conference*, p72:282-298 (1972).

14. Turn, R. and Z. Shapiro. "Privacy and Security in Databank Systems - Measures of Effectiveness, Costs, and Procetor - Intruder, Interactions." *Proceeding, Fall Joint Computer Conference* 41:435-444 (1972).

VI. REFERENCES

IV. 4 LARGE MEMORIES

1. Dell, H. R. "Design of a High Density Optical Mass Storage System." Computer Decisions, 10:49-53 (1971).

2. Gentile, R. B. and J. R. Lucas, Jr. "The TABLON Mass Storage Network." Proceedings, Spring Joint Computer Conference, 38:345-356 (1971).

3. Gross, W. A. "Ultra-large Storage Systems Using Flexible Media, Past, Present and Future." Proceedings, Spring Joint Computer Conference, 40:357-367 (1972).

4. Harker, J. M. & H. Chang. "Magnetic Moles for Bulk Storage - Past and Future." Proceedings, Spring Joint Computer Conference, 40:945-955 (1972).

5. Katzan, H., Jr. "Storage Hierarchy Systems, "Proceedings, Spring Joint Computer Conference, 38:325-336 (1971).

6. Label, and M. V. Farina. "Selecting Computer Memory Devices." Automation, 17:66-70 (1970).

7. Penny, S. J., R. Fink and M. Alston - Garnjost. "Design of a Very Large Storage System." Proceedings, Fall Joint Computer Conference, 37:45-51 (1970).

VI. REFERENCES

IV. 5 INFORMATION ACCESS

1. Bennett, J. L. "On Line Access to Information: NSF as an Aid to the Indexer/Cataloger." American Documentation, 20:313-220 (1969).

2. Bosen, S. E. "A Video Dial Select System that Works", Educational Television, v. 3, n.9.

3. Collmeyer, A. J. and J. E. Shemer. "Analysis of Retrieval Performance for Selected File Organization Techniques." Proceedings, Fall Joint Computer Conference, 37:201:210 (1970).

4. Frisch, J. "Bit Vectors Vitalize Data Retrieval." Data Dynamics, 13:37-41 (1971).

5. Lum, V. Y., H.Ling, and M. E. Senko. "Analysis of a Complex Data Management Access Method by Simulation Modeling." Proceedings, Fall Joint Computer Conference, 37:211-222 (1970).

6. Lum, V. Y., P.S.T. Yueu, and M. Dodd. "Key-to-Address Transform Techniques: A Fundamental Performance Study on Large Existing Formatted Files." Communication of ACM, 14:228-239 (1971).

7. Mullin, J. K. "An Improved Index Sequential Access Method Using Hashed Overflow." Communication of ACM, 15-301-307 (1972).

8. Niles, A. M. "Dial-A-Tape for Continuing Education." NUEA Spectator, 36-18.

9. Price, C. E. "Table Hookup Techniques." Computer Survey, 3:49-65 (1971).

10. Reuter, A. "A Simplified Dial-A-Tape Program for School and Home Instruction", Educational Technology - Teacher and Technology Supplement, 12:60-61 (1972).

VI. REFERENCES

IV. 6 INFORMATION RETRIEVAL SYSTEM

1. Back, H. B. "What Information Dissemination Studies Imply Concerning the Design of On-Line Reference Retrieval Systems." Journal of the American Society for Information Science, 23:156-163 (1972).

2. Barber, R. "A Retrieval System for Product Data." The Information Scientist, 104:3-10 (1970).

3. Houghton, Bernard, ed., Computer Based Information Retrieval Systems. Hamden, Archon Books, 1969.

4. Hoffman, W. S. "Du Pont Information Flow System." Journal of Chemical Documentation, 12:116-124 (1972).

5. Jardine, N. and C. J. Van Rijsbergen. "The Use of Hierarchic Clustering in Information Retrieval." Information Storage and Retrieval, 7:217-240 (1971).

6. Johnson, C. and E. Briggs. "Holography as Applied to Information Storage and Retrieval Systems." Journal of the American Society for Information Science, 22:187-194 (1971).

7. Landauer, W. I. "The Balanced Tree and its Utilization in Information Retrieval." Transactions on Electronic Computer of the IEEE, 12:863-871 (1963).

8. Negus, A. E. and J. L. Hall. "Towards an Effective On-Line Reference Retrieval System." Information Storage and Retrieval, 7:249-270 (1971).

9. Negus, A. E. "A Real Time Interactive Reference Retrieval System." The Information Scientist, 5:29-44 (1971).

10. Squires, G. "Information Retrieval at Sub-Document Level." British Journal of Educational Technology, 2:211-215 (1971).

11. Walston, C. E. "Information Retrieval." Advances in Computers, 6:1-28 (1965).

12. Williams, J. H. Jr. "Functions of a Man-Machine Interactive Information Retrieval System." Journal of the American Society for Information Science, 22:311-317 (1971).

VI. REFERENCES

IV. 7 AUTOMATION

1. A System Study of Abstracting and Indexing in the United States, System Development Corporation, 1966. PB174249.

2. Correcting Codes for Exchange of Information Between Computers, NTIS, May, 1972. 10 pp AD-747-723.

3. Douglas, R. L. "Aims and Techniques of Computer - Aided Automatic Assembly," Automation, 18:34-36 (1971).

4. Edmundson, H. P. and R. E. Wyllys. "Automatic Abstracting and Indexing." Survey and Recommendations." Communications of the ACM, 4:226-235 (1961).

5. Edmundson, H. P. "New Methods in Automatic Extracting." Journal of the Association of Computing Machinery, 16:265-285 (1969).

6. Harding, W. J. and T. H. Howell. "Performance Analysis of Error-Detecting and-Correcting Codes in a Random-Error Environment," Proceedings of the ACM National Conference, p72:265-277 (1972).

7. Lignos, D. "Error Detection and Correction in Mass Storage Equipment," Computer Decisions, 11:71-75 (1972).

8. Rush, J. E., R. Salvador and A. Zamera. "Automatic Abstracting and Indexing. II. Production of Indicative Abstracts by Application of Contextrial Inference and Synthetic Coherence Criteria." Journal of the American Society for Information Science, 22:260-274 (1971).

9. Stevens, M. E., "Automatic Indexing: A State of-the-Art Report." N.B.S. Monograph 91, Washington, D. C., 1965.

10. Wallner, A. "Error Detection for Peripheral Storage Devices." Computer Decisions, 11:57-61 (1972).

11. Wyllys, R. E., Research in Techniques for Improving Automatic Abstracting Procedures. Santa Monica, Calif., System Development Corporation, 1963.

VI. REFERENCES

IV. 8 APPLICATIONS OF COMPUTERS IN EDUCATION

1. Beattie, A. W. "Thought on the Computer and Education." Data Processing for Education, 1: 1-3 (1962).

2. Berkeley, E. D. "The Romance of the Good Teaching and the Time-shared Computer." Computers and Automation, 14:12-17 (1965).

3. Bryan, G. L. "Computers and Education," Computer and Automation, 18:16-19 (1969).

4. Braunfeld, P. G. "Problems and Prospects of Teaching with a Computer," Journal of Educational Psychology, 55:201-211 (1964).

5. Bushnell, D. D., R. de Mille, and J. Purl. "The Application of Computer Technology to the Improvement of Instruction and Learning." In Educational Implications of Technical Change. Washington, D.C. U.S. Government Printing Office, 1966 V. IV, pp 1-28.

6. Bushnell, D. D. "Applications of Computer Technology to the Improvement of Learning." In Bushnell, D. D., ed, The Computer in American Education, New York: John Wiley and Sons, Inc. 1967.

7. Bushnell, D. D. "Computers in the Classroom." Data Processing, 4:9-14 (1962).

8. Bushnell, D. D., and D. W. Allen, ed, The Computer in American Education. New York; John Wiley, 1967.

9. Bushnell, D. D. "Computers in Education." Computers and Automation, 12:(1963).

10. Bushnell, D. D. "The Role of the Computer in Future Instructional Systems." AV Communication Review, 11:(1963).

11. Chapman, R. L. and J. T. Carpenter. "Computer Techniques in Instruction." In Programmed Learning and Computer-Based Instruction. New York: Wiley, 1962 p. 240-253.

12. "Computer-Based Laboratory for Learning and Teaching." Automated Education Letter, 1: (1965).

13. Computers and Education. New York; Science Associates/International Inc.,1970.

14. Feurzeig, W. "The Computer that Talks Like a Teacher." Journal of Accounting, 117:27-28 (1964).

15. Gerard, R. W. Computers and Education. New York; McGraw-Hill, 1967.

(continued)

APPLICATIONS OF COMPUTERS IN EDUCATION

16. Goodlad, J. I., J. F. O'Toole, Jr., and L. L. Tyler. Computers and Information Systems in Education. New York; Harcourt, Brace and World, Inc., 1966.

17. Grossman, A., "New Approach to Guidance Research Using an Electronic Computer. "California Journal of Education Research, 13:(1962).

18. Hall, J. Computers in Education, New York; Pergamon Press, 1962.

19. Hansen, D. N. "Applications of Computer to Research on Instruction." Paper Presented the National Society of College Teachers of Education, Chicago, February 1966.

20. Hansen, D. The Role of Computers in Education During the 70's. Technical Memo 15, CAI Center, Tallahasee, Florida State University, May, 1970.

21. LePage, W. R. "Applications of Time-Shared Computing in Education," Large Scale Information Processing Systems: vol. IV Computers and Education. Springfield, Va.: Clearinghouse, pp. 1-40 1968.

22. Scott, C. R. "Computer as a Tool of Education." American Business Education 43: (1963).

23. Silberman, H. F. "The Digital Computer in Education," Phi Delta Kappan, 43: (1962).

24. Suppes, P. "The Uses of Computers in Education." Scientific American 215: 206-220 (1966).

25. Theobald, R., and R. W. Tyler. "Higher Education and Cybernetics." NEA Journal 55:26-29 (1966).

26. Zinn, K. L. "Instructional Uses of Interactive Computer System." Datamation, 14-22-27 (1968).

27. Zinn, K. L. "Programming Conversational Use of Computers for Instruction." Proceeding of ACM 23rd National Conference, 68: 85-92 (1968).

VI. REFERENCES

IV. 9 INFORMATION DISSEMINATION

1. Commission on Scientific and Technical Information. Progress in Scientific and Technical Communications. Washington, D. C., Federal Council for Science and Technology, 1969. ED 034 691.

2. Dumas, Neil. Research Utilization and Dissemination; Proceedings of a Regional Conference. Gainesville, Florida; University of Florida, 1968. ED 024 992.

3. Entelek, Inc. Computer Assisted Instruction Information Exchange, Final Report. Newbury, Massachusetts; Entelek, Inc. 1970. ED 038 862.

4. Farr, R. S. Knowledge Linkers and the Flow of Educational Information. Stanford, California, Educational Resources Information Center, 1969 ED 032 438.

5. Green, L. A. Educational Technology Dissemination Project in Selected Methods of Disseminating Information Regarding Educational Media by the State Department of Education. Denver, Colorado, Colorado State Department of Education, 1966. ED 021 481.

6. Grimes, George. Regional Information System for Educators, Information Resources, Installation, and Evaluation. Detroit, Michigan, Michigan-Ohio Regional Educational Laboratory, 1969. ED 033 613.

7. Havre. Dissemination Strategies and Devices, Part Four; Final Report for Phase I, Rural Shared Services. Portland, Oregon, Northwest Regional Educational Laboratory, 1969. ED 028 882.

VII. LIST OF SOURCES CHECKED

I. Indexes

Education Index, 1972

Government Reports Index, 1970-1972

Government Reports Announcements, 1970-1972

Quarterly Bibliography of Computers and Data Processing, 1970-1973

Computer and Education, (Book) 1970

II. Serials

Advances in Computers, 1965-1972

American Documentation, 1969

American Educational Research Journal, 1969-1970

British Journal of Educational Technology, 1971

College and University Business, 1972

Educational Documentation and Information, 1971

Education Digest, s 1971-My 1972

Educational Screen and Audio Visual Guide, 1971

Educational Technology, 1970-1972

EDUCOM, 1966-1973

Engineering Education, 1972, 1973

Information, 1970

Information and Control, 1972

Information Sciences, 1972

Information Science Abstracts, 1972-1973

The Information Scientist, 1972-1973

Information Storage and Retrieval, 1971-1973

Journal of the American Society for Information Science, 1969-1972

Journal of Chemical Documentation, 1972

Journal of Computer and System Sciences, 1970-1971

Journal of Education for Librarianship, 1971-1972

Journal of Educational Data Processing, 1968-1970,1972

Journal of Educational Research, S 1969-1972

Journal of Educational Technology, 1970

Journal of Research and Development in Education Fall 1971-Summer 1972

III. Output of ERIC Tape Search

Current Index to Journals in Education 1972

Eric Educational Documents Index (1966-1969)

APPENDIX

A. SAMPLE OF LETTER REQUESTING INFORMATION

Georgia
Institute
of
Technology SCHOOL OF INFORMATION AND COMPUTER SCIENCE / (404) 894-3152 / ATLANTA, GEORGIA 30332

Dear

We are currently working on a NSF sponsored project, the objective of which is to study, design, and experimentally evaluate man-machine mechanisms for enhancing the transfer of science information from its present repositories into science learning systems. In particular, we plan:

1. To describe operationally the process of transformation of science information system outputs for the purpose of integrating them into the content of science learning systems (i.e., computer based as well as routine class-room type educational systems).
2. To investigate comparatively the design and operating characteristics of science information systems and science learning systems, particularly from the viewpoint of requirements for transferring information between them via a man-machine interface.
3. To implement an experimental design of limited transfer mechanism from appropriate existing science information systems into science learning systems and to evaluate the cost effectiveness of that mechanism.

To achieve the above-stated goals of our project, we collect and analyze information on the following topics:

1. State-of-the-art of computer based science learning systems, their operational characteristics, teaching procedures and the methodology of course preparation in the concerned science learning system.
2. State-of-the-art of existing operational science information transfer mechanisms, and the procedural details involved.
3. Details of the forms of available outputs from the science information repositories to learner/educator communities.

It will be greatly appreciated if you can send us whatever relevant documents and reports are available at your center on the above-mentioned topics. If you have any questions regarding our project or information we are requesting, please call us collect.

Thank you for your assistance.

Sincerely yours,

Pranas Zunde
Project Director
School of Information and Computer
Science

B. INSTITUTIONS CONTACTED BY LETTER OR PHONE

Dr. James J. McCarthy, Project Director
Special Education Instructional
Materials Center
University of Wisconsin
415 West Gilman
Madison, Wisconsin 53706

Dr. M. Thomas Risner, Director
National Information Center For Education
Media
University of Southern California
University Park
Los Angeles, California 90007

Mr. H. E. Baker, General Manager
Scientific and Technical Information
Facility
NASA
5001 Calvert Road
College Park, Maryland

Mr. Jerry Harrison
NASA
Technology Utilization Ofc.
Code KT
Washington D.C. 20546

Mr. Colin Mick
Institute for Communication Research
Cypress Hall
Stanford University
Stanford, California 94305

Albert W. Fell, Director
Special Education Instruction
University of Texas
304 West 15th Street
Austin, Texas 78701

Mr. T. Kottenstett
Denver Research Institute
2050 E. Iliff Avenue
Denver, Colorado 80210

Miss Becky Walker
North Carolina Science & Technology
Research Center
Research Triangle Park, N. C. 27709

Clearinghouse for Federal Scientific &
Technical Information
Springfield, Virginia 22151

C. VISITOR FROM INSTITUTE OF LIBRARY RESEARCH

Mr. Allen Humphrey of the Institute of Library Research, University of California at Berkeley, visited the campus on April 5. In conference with the staff of STITE he discussed the work of the Institute and more particularly his participation in a study of the Educational Resources Information Center conducted by the Institute.

The primary purpose of the Institute of Library Research is to investigate the application of technology to library practices, Mr. Humphrey explained; and he has been involved with a number of their research projects, including the development of an information processing system and a bibliographic file procedure, both of which are used in laboratory practice by library school students. He also worked on a lesser project in contextual indexing and on the production of a union catalog in book form for the nine libraries of the University of California system.

For the purposes of the STITE project, Mr. Humphrey's association with ERIC was most relevant. ERIC is a nationwide decentralized information system designed to disseminate and promote the use of educational information. *Research in Education* processes approximately 1,000 items per month on magnetic tape, excluding journal articles, and *Current Index to Journals in Education* processes approximately 1500 items from journals each month. Both indexes receive their materials from 16 clearinghouses over the country, each clearinghouse having its own subject specialization. In addition, the clearinghouse on vocational and technical education information produces AIM and ARM, abstracts of instructional and research materials in that field.

Approximately 100 organizations presently receive ERIC tapes regularly, of which 25 to 30 are active users. Users are primarily state or regional education agencies that service requests from the education community and universities and colleges that service requests from professors and students of the academic community.

Direct utilization of ERIC Tapes by the STITE project was discussed, without conclusions. Technology presently exists for some possibilities, such as the direct transmission of a bibliography for updating a course to a teacher at a terminal, but further investigation will be required to assess the potential of ERIC tapes for STITE purposes.

D. Interview at National Medical Audiovisual Center

Name of Interviewee: Mr. Robert T. Turnbull
Audiovisual Systems Analyst
NMAC
Time and Date: Tuesday, April 3, 1973
Interviewing Persons: N. V. Subramanian and Khalid Hafiz
Notes of the interview are written by:
N. V. Subramanian
Research Analyst
School of Information and Computer Science
Georgia Institute of Technology

In the opening of the interview, the overall objectives of the project, STITE, were explained and in particular the concern of the project with educational systems and the analysis of audiovisual systems used for educational purposes.

Mr. Turnbull initially discussed at length the details of the equipment displayed in the Learning Resource Center at NMAC. Then he gave cost figures for that equipment. One interesting fact he mentioned was that in designing some of the new systems, the time factor involved makes it obsolete by the time it is ready to operate. This necessitates very frequent updating of the information content of the particular audiovisual learning system which, in turn, incurs some additional personnel costs.

Mr. Turnbull also mentioned that, in the case of audiovisual systems which use slides of models, the production of the models and of the slides should be artistically well done; otherwise the learner-participants find the system psychologically repulsive and the intended goals may not be achieved. In order to achieve the intended goals of artistic acceptability in designing an audiovisual presentation, considerable cost is incurred. Mr. Turnbull further added that in years to come, when the cost of the audiovisual equipment decreases substantially, there is a great potential in the widespread use of audiovisual techniques in the learning of medicine. He also implied that such use of audiovisual learning systems can be extended to several other fields of science and technology.

In the course of the interview, Mr. Turnbull explained and demonstrated the mobile audiovisual center (CML-10), 3M study carrel, Aeonstic carrel, No. 200 series A-1, and closed circuit TV educational programs.

In the concluding part of the interview, Mr. Turnbull expressed his opinions about Science information transfer for education from Science information repositories. He strongly felt that local institutions for years to come have to bear the design and developmental responsibilities of audiovisual learning systems, using whatever information they can procure from science information repositories. He also felt that there is some unwillingness on the part of institutions that design and develop such systems to offer them freely to other institutions in a different geographical location.

From this interview, it is inferred that local educational institutions must bear the responsibility for transforming information that is available from science information centers into structures that can be used in their particular educational systems. There are some implications of NMAC for the STITE project. In the future, the video-tapes, movies and slides of technological experiments and medical operations which are otherwise difficult to conduct, or even to simulate, at educational institution can be delivered to educators from Research Centers and the Science information systems for the benefit of the educator community. In addition when the cost of data transmission, and particularly the cost of picture and graphic data transmission, decreases considerably, it will be feasible to have on line tranmission of knowledge from science information systems to the learner community.

In the concluding part of the interview, Mr. Turnbull gave us the following catalogs:

1. "Toward Improved Learning," vol. 1, vol. 2, U.S. Department of Health; Education and Welfare/Public Health Service.
2. Motion Picture Film Catalog.
3. Videotape Catalog.

The above catalogs explicate the details of the design of such audio-visual learnirg systems.